# A Human-centric Accessible eHealth Booking Web Portal

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Abstract: The use of eHealth web portals is rapidly increasing with the extensive demand for eHealth services and established benefits of using health-related software. Unfortunately, most of these applications underestimate or even ignore Human-centric issues (HCIs) and thus result in a system that is not fit-for-purpose. This emphasises the importance of allowing for diverse end-users characteristics, such as age, gender, culture, occupation, and cognitive impairment, when designing eHealth web portals. In this paper, we describe a study we conducted involving a preliminary survey in three languages to determine different users' needs, taking into account their human-centric issues. We designed an e-booking prototype and evaluated it with user studies. Our results suggest that age and language are the most crucial human-centric aspects to be considered when developing an eHealth web portal. The study also provided recommendations for appropriate web design elements for building human-centric eHealth applications.

## 1 INTRODUCTION

With the expansion of the World Wide Web 2.0, awareness of and demand for eHealth has increased dramatically. People use eHealth applications to derive valuable health information or services and manage health conditions (Schnipper et al., 2008; Van Gemert-Pijnen et al., 2013). However, eHealth applications that do not consider human-centric issues (HCIs) are less likely to be fit-for-purpose (Grundy et al., 2020) and commonly fail because they were developed without carefully considering HCIs during their deployment stages (Shamsujjoha et al., 2021).

This study presents how human-centric aspects might be incorporated in the design of eHealth portals with a specific focus on accessibility. We aim to identify the significant gaps among human-centric aspects in eHealth web portals, increase inclusiveness for diverse users, and provide recommendations for applying the essential human-centric aspects into eHealth web development. Fundamental human-centric aspects such as age, gender, culture, occupation, and cognitive impairment are the main target factors in analysis. The research focuses on end-users, usually the primary user groups, during the application life cycle.

To capture a snapshot of the current state-of-play, we reviewed a set of 44 existing eHealth web portals in July of 2021 and compared the results to preliminary survey results from 138 diverse end-users. The survey was designed in three languages to increase the entries of people from different backgrounds and collect their preferences on colour tone, icon design, navigation style, and typography. We found that most eHealth websites were yet to meet different users' needs. We implemented an e-booking prototype based on the user preferences and requirements in the survey and evaluated the human-centric issues through 16 user studies.

By analysing the HCIs, we introduced an integrated "Accessibility Helper" to increase diverse users' access to eHealth web portals. We considered which features (e.g. changing primary colour, enlarging font size) were the most popular and necessary settings, and which design elements (e.g. skeuomorphism, flat, material) were the most practical design. Based on the results, the research findings improved the user experience of different users and increased the efficiency and frequency of eHealth services. The

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main contributions of this research are as follows:

- We explored the essential human-centric issues which led to the eHealth web portals failing to fit different people's needs and how these issues affected users' experience.
- We collected the real-world eHealth websites that were frequently used in three different countries when conducting this research and summarized their general web design elements.
- We identified the different preferences on design elements, such as colour, navigation, iconography, considering different users' needs.
- We developed an all-built-in-one assistant, "Accessibility Helper", for integrating multiple web accessing features to fulfil different users' needs.

# 2 BACKGROUND

## 2.1 eHealth Web Portals

In the 1990s, the term "eHealth" was defined as a combination of Information Communication Technology (ICT) and healthcare (Oh et al., 2005). The demand for online healthcare has seen explosive growth since the rise of Web 2.0, in which 80% of online users seek out health services, particularly in times of health crises (Akerkar and Bichile, 2004; Van Gemert-Pijnen et al., 2013). The benefits of eHealth applications are highlighted as i) avoiding delays in detection of potential diseases and reducing possible human errors in treatments (Schnipper et al., 2008); ii) replacing heavy paper-based records and managing healthcare data efficiently for nurses and professionals (Goel et al., 2011); and iii) increasing access to share or discuss similar symptoms among potential users and reducing time sourcing health information (Ancker et al., 2011). All of these benefits increase the possibilities for large-scale health research and an improvement in health.

In particular, eHealth web portals are widely together with mobile health-care apps, namely mHealth, due to i) engaging data visualization and interaction for the end-users (Boulos, 2003); ii) authoritative healthcare information or services provided by professionals (Das et al., 2015); and iii) increasing accessibility for more senior users who seek healthcare guidance via portals (Gordon and Hornbrook, 2018). Web-based booking systems, a win-win solution for patients and medical clinics, are the starting point for most non-urgent healthcare services. The e-scheduling software brings specific positives such as a reduced no-show rate, decreased waiting time and staff labour, and increased decision-making freedom for patients' preferred time and/or medical professional (Paré et al., 2014; Zhao et al., 2017). Unlike appointments via phone, booking via emails or health-related applications is an much preferred alternative for some patients, for example autistic people since they may have limited verbal capacity and experience anxiety when communicating with strangers (Bradshaw et al., 2019).

## 2.2 Human-centric Issues on eHealth Web Portals

Applications and software systems should be designed and built to allow for human individuality (Kotronis et al., 2019). In terms of human-centric aspects, they refer to age, gender, language, culture, emotions, personality, education, occupation, physical and mental challenges, and cognitive impairment (and other traits) (Grundy et al., 2020). Human-centric issues (HCIs) refer to the problems brought about by a failure to consider and adapt software for human-centric aspects (Shamsujjoha et al., 2021).

For instance, there is an increased prevalence of cognitive degeneration associated with ageing (Góngora Alonso et al., 2020), people aged 65 and over (Au et al., 2017) who, in Australia, are mainly female. Given most software developers are male in their 20's (Grundy et al., 2020), who are less likely to develop software that identifies distinctive characteristics for diverse end-users (Venkatesh and Morris, 2000; Schnipper et al., 2008; Smail-Crevier et al., 2019), it is not uncommon for software to be less inclusive for older Australians. The lack of access to fit-for-purpose software to monitor their health can lead to a negative user experience and potentially worse health outcomes as a consequence. Specific cases include patients with cancer who have identified a preference for personalised eHealth tools, as many have identified they are no personalised settings in the tools they used (Van Gemert-Pijnen et al., 2013).

Apart from the eHealth background in academic literature, reflecting available online health systems in the open market as part of the research is vital (Maramba et al., 2019). We collected 44 eHealth websites that were mostly used in Australia, Korea and China and comparing the design of those websites with a preliminary survey we conducted to collect different users' preferences on eHealth web portals, more details of which will be discussed in the following section.

# 3 METHODOLOGY

Questionnaires are still the most frequent approach of usability evaluation in the eHealth field, followed by task completion and the 'Think-Aloud' method (Maramba et al., 2019). For this reason, the research was conducted using quantitative and qualitative analysis. The workflow of this study is i) A preliminary survey was conducted in three languages to understand diverse users' preferences/needs and how they feel about the current eHealth portals; ii) The survey results were compared with the collection of the top eHealth webs to see the gaps on real-world eHealth webs; iii) An eHealth web prototype designed based on the survey responses; and iv) Several user studies for the prototype using a 'Think-Aloud' protocol. We guide the study by answering the following research questions:

- What human-centric aspects are essential for eHealth webs? (Section 4)
- How a prototype take into account these human-centric aspects? (Section 5)
- How to evaluate such a prototype considering human-centric aspects? (Section 6)

# 4 RQ1: WHAT HUMAN-CENTRIC ASPECTS ARE ESSENTIAL FOR eHEALTH WEBS?

## 4.1 Preliminary Survey

### 4.1.1 Data Collection

An anonymous survey was conducted via Google Forms in English and Korean, and Wenjuanxing[1] in Chinese to explore a range of answers from people from diverse backgrounds. We invited eHealth web stakeholders such as medical practitioners, researchers, and general users from diverse cultures, ages, genders and occupations. There were no exclusion criteria at this stage.

The preliminary survey was designed and divided into three parts as follows: i) The participants responded if they had used an eHealth website: if YES, they were asked to leave their impression - using emotional language like trust, surprise, neutral, fear, anger - and comments about the eHealth website they had used recently; if NOT, they were asked their perspectives of three sample health-related websites suggested by the authors. The three samples were selected because of their different user interface designs; ii) We provided screenshots of different online eHealth setting examples in the questionnaire. The participants were asked the purpose of their eHealth application use, and to choose their preferences regarding the colour theme, font size, navigation design and icon design (see Figure 1). They were asked to provide information about their specific devices beforehand as the font size may vary depending on their responsive devices; and iii) Data about their demographics such as age, gender, education, language, occupation, and whether they had any chronic health conditions, were collected.


(a) Colour tones (b) Navigation

(c) Icon design

Figure 1: Screenshot of part of the preliminary survey, asking for UI preferences.

The aim was to analyze and understand which human-centric aspects should be considered when developing an eHealth application based on the data and preferences of the end-users preferences. We received 146 responses within two weeks of posting the questionnaire on Social media platforms such as Linkedin, Wechat, and Kakao Talk. Extracted responses were recorded on a spreadsheet for data preparation, with each row representing one participant's entry. The study was approved by the Monash University Human Research Ethics Committee.

[1] Wenjuanxing: Online survey platform. Retrieved from: https://www.wjx.cn/

#### 4.1.2 Data Analysis

Firstly, the researcher whose main language is Chinese/Korean translated the responses from the Chinese and Korean surveys into English and merged them into the English survey for data preprocessing. Of all the returned questionnaires, eight were deleted because two were test answers before officially releasing the surveys, and six were invalidated answers that revealed inconsistency among responses demonstrating possible biases between occupation and frequency of online access. At this stage, we had a final set of 138 valid responses for further data analysis. We cleaned the dataset using Microsoft Excel and performed quantitative analysis using Python and SPSS[2] with Chi-square. Each human-centric aspect was analysed individually to see which arguments had significant results and to determine any relationships between multiple arguments.

### 4.2 Survey Results

#### 4.2.1 Demographics

Except for two participants who preferred not to identify their gender, the distribution of gender was 61% female and 38% male, 55% of them were aged from 18 to 35, while 45% were aged over 35. Among all the participants, 84% of them had experience with eHealth applications, and 22.5% disclosed a self-reported chronic health condition.

People from nine different nationalities filled in the survey. They reported having 18 occupations such as government employee, IT developer, home duties, health professional, researcher, student, and retired. Among the sample, 83% lived in urban areas, and 66% self-reported their Internet speed as fast to very fast and held a college or bachelor degree. They self-evaluated their basic computer skills as moderate to high/very high as 51% and 38% respectively, and 85% of them reported to be daily active users.

#### 4.2.2 Age

Among all the human-centric aspects, older age was associated with significant differences for preferences with colours, icon and navigation design. We performed a chi-square analysis and found that advancing age and icon design were significantly related ($p = 0.01$), which showed a dramatically increasing trend of preferring skeuomorphic design with advancing age (see Figure 2).

[2]SPSS Online: data analysis tool. Retrieved from: https://spssau.com/en/index.html

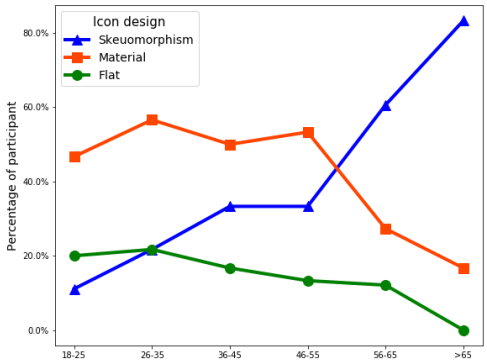



Figure 2: Correlation between age groups and icon design preferences.

However, there was no significant difference detected in preferences for Colour theme or Navigation design. The elderly had a strong preference for warm colour toned web pages while 18 to 65 aged people were more likely to choose cool colour themes. It was possible that the colour preferences among elderly were more likely to be based on their visual perception rather than their fondness of that colour. Regardless of age, both icon and text remained the most favourite navigation design, which may be because both icon and text revealed more transparent navigation than icon only and were a more impressive design than text only.

#### 4.2.3 Other Human-centric Aspects

Although there was no significant difference for other human-centric aspects, our results describe other human-centric aspects (other than age) including:

**Chronic Health Condition -** the only significant result found in people with chronic health conditions was icon design ($p = 0.001$). Results showed that 42% of those who answer positively to chronic health conditions would prefer Skeuomorphism. Those who responded "Yes" and "Unsure" shared similar preferences, of which around 70% preferred the bigger font size. The reason for the font size preference may be due to a high correlation between having a chronic health conditions and being an older adult.

**Gender -** we did not find any significant differences between genders since they shared the same pattern of preferences. Female and male participants' preferences for cool colour were 55% and 52%, and warm was 39% and 40% respectively. Similarly, their preferences for icon design were 20% and 21% for Flat, 44% and 42% for Material, 33% and 37% for Skeuomorphism. Interestingly, they both had a strong preference for both icon and text (85% and 79%).

**Occupation -** there were no significant results found for occupation. Surprisingly, students were the group

that most frequently picked "No preferences" while the other occupations had preferences for colour and icon design. As for those who are IT developer and designer, colour theme was generally the most important feature compared to icon design and other web design elements.

# 5 RQ2: HOW A PROTOTYPE TAKE INTO ACCOUNT THESE HUMAN-CENTRIC ASPECTS?

## 5.1 Real-world eHealth Webs

To see the gaps between real-world eHealth web portals and HCIs, we collected the top eHealth websites in Australia, Korea from App Annie[3] and China from Top.chinaz[4], and eHealth websites collected from the preliminary survey that will be discussed in the following section.

Forty-four eHealth websites were collected and reviewed by the first author on their colour tones, icon design, navigation design, language and font size, and cross validated by two of the other authors. Compared to the results from 44 online eHealth web and survey respondents, it was evident that there was a big gap between what the end-users need and what the online applications looked like (see Figure 3-5). This included e-booking systems which this study is using as an example for how to address HCIs in eHealth development.

## 5.2 e-Booking Prototype

Based on the preliminary survey analysis, we designed an e-booking system prototype using Figma[5]. The prototype followed Web Content Accessibility Guidelines (WCAG) V2.0 Level AAA (Isa et al., 2016). We introduced features, *Language*, *Colour theme*, *Dark mode*, *Enlarge text*, *Voice Assistant* and *Simplify design* for the user to modify the website based on their personal preferences.

As for the layout of "Accessibility Helper", we provided two designs for the users: a robot design

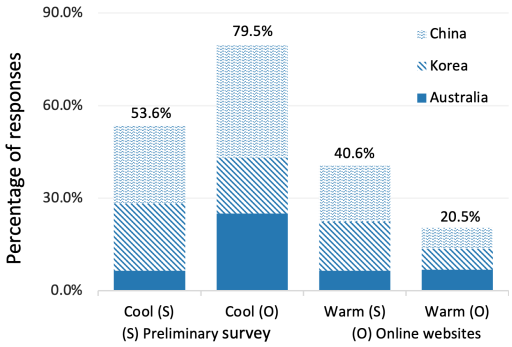



Figure 3: Gaps on colour between the design of online applications and the preferences from preliminary survey. 79.5% online websites are using *cool* colours, which is consistent with the result that most participants in the survey preferred *cool* colours.

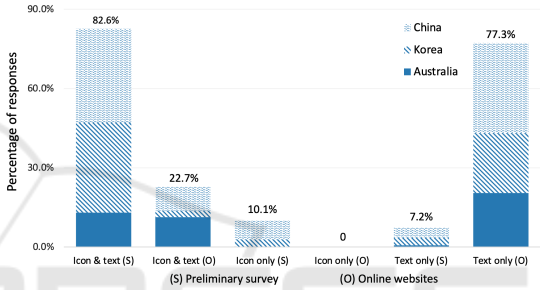



Figure 4: Gaps on navigation style between the design of online applications and the preferences from preliminary survey. 82.6% participants preferred *both icon & text* style reported in the survey, while 22.7% online eHealth websites designed in *both icon & text*. Instead, 77.3% online websites designed in *text only*.

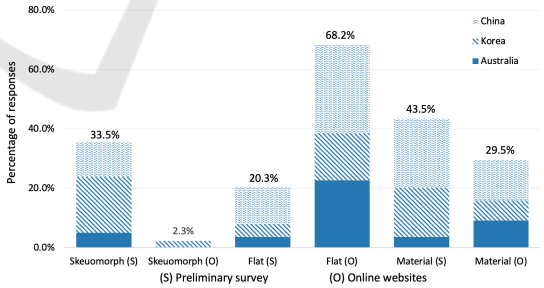



Figure 5: Gaps on icon design between the design of online applications and preferences from preliminary survey. 33.5% participants preferred *skeuomorph* design in the survey, while one online website (2.3%) adapted *skeuomorph* design. 68.2% of online eHealth websites designed in *flat* icon, while only 20.3% participants preferred *flat* design reported in the survey.

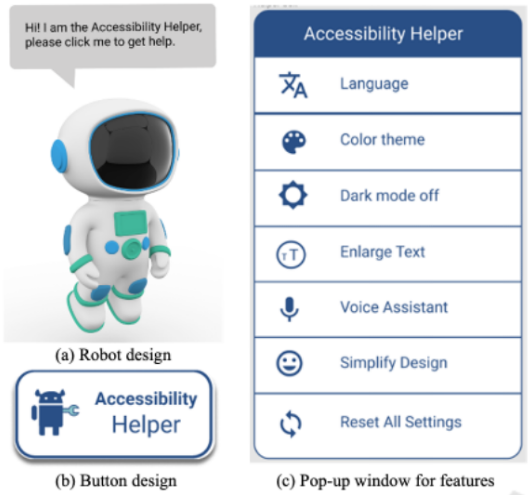
(Figure 6a) when the user first accessed the page and the other one is a button design (Figure 6b) when the user continued to browse the page. After clicking either design of "Accessibility Helper", a pop-up win-

[3]App Annie: Application/Web data analytics platform. Top eHealth web usage in Australia and Korea. Retrieved from http://AppAnnie.com. (data collected by July 25, 2021)

[4]Top.chinaz: Website ranking analytics platform. Top eHealth web usage in China. Retrieved from http://top.chinaz.com. (data collected by July 25, 2021)

[5]Figma: Interface design tool. Retrieved from: https://www.figma.com/

dow (Figure 6c) lists all the corresponding features. The summary of each feature in the extended tool "Accessibility Helper" is listed below:




(a) Robot design (b) Button design (c) Pop-up window for features

Figure 6: Screenshot of Accessibility Helper.

**Language -** There is only an English-Chinese translation in this prototype, each web page of it was designed in both English and Chinese. User could applied either language and the first author manually did the translation of the web page.

**Colour Theme:** We applied the colour palette, which allows users to feature the significant colour of the web page. Users were able to choose from 70 different colours, which were pre-defined in the primary colour palette. Moreover, they could also customise their preferred colours after clicking "More colour" option.

**Dark Mode:** Similarly to the Colour theme, we also performed light-on-dark colour schemes, namely Dark Mode. The user was able to select this option to convert all text, icons, and elements light-colour to a dark background.

**Enlarge Text:** Participants could control a scroll bar to enlarge the font size of the web page. As the preferences on font size varied in the preliminary survey, there was a need to have a wide range of font sizes collected from 8pt to 22pt.

**Voice Assistant:** Since there is no natural language processing (NLP) tool in Figma, the first author simulated this for the user study, which would be considered for implementation in future research. When the users accessed the web page, if they would like to have voice instruction, they were able to click the feature for requiring voice assistance which the author simulated.

**Simplify Design:** From the preliminary survey, most participants, regardless of their age, felt more hesitant and struggled when seeing too many navigation options or context on a web page. Therefore, we included a Simplify design feature to minimise three different navigation bars into two and shorten multiple lines of text into three lines.

**Reset All Settings:** This enabled all customised features to go back to the default setting with English content, blue colour theme (due to 68% of 44 online eHealth webs mentioned in the background section are designed in blue), 10pt font size (due to most participants responded to it in the preliminary survey), simplify design and dark mode off.

# 6 RQ3: HOW TO EVALUATE SUCH A PROTOTYPE CONSIDERING HUMAN-CENTRIC ASPECTS?

## 6.1 User Study Design

We performed 16 user studies with participants from different demographic backgrounds to investigate the usability of the prototype. Participants were recruited if they positively responded to a subsequent user study invitation in the preliminary survey or a secondary recruitment advertisement on social media. To increase the reach of the survey, the only eligibility criteria was being able to access the Internet.

The user study was conducted via different Zoom sessions and held for 30 (±5) minutes on average. Each session began with a brief explanation, consent from the participant and instructions about the user study mediated by the first author, followed by some basic tasks and a corresponding questionnaire completed by the participants. The study was approved by the Monash University Human Research Ethics Committee. The questionnaires were created in two languages -English via Google Form and Chinese via Wenjuanxing- by the first author. The other languages such as Korean will be discussed in the future.

The questionnaire was divided into two parts: i) the basic background information including age, gender, whether they have any chronic health issues and a simple vision test; and ii) four major tasks of applying personalised features through "Accessibility Helper" for the website layout before booking an appointment. Those four steps included changing colour theme, adjusting font size, setting dark mode, and applying multi-language translation. During the tasks, each participant was instructed to share his/her screen and encouraged to state what they were thinking as per the 'Think-Aloud' approach (Eccles and

Arsal, 2017), while the first author recorded their statements. The accessibility of the prototype was evaluated through the participants' statements during the tasks and their self-reported evaluation of the questionnaire. In order to evaluate the prototype, we categorised four domains from the software quality characteristics including *Effectiveness*, *Satisfaction*, and *Efficiency* (Ferreira et al., 2020) and *Adaptation* which emerged from the analysis. The evaluation criteria are examined (see Table 1).

Table 1: Evaluation criteria of the user study.

| Domain | Domain Description |
|---|---|
| Effectiveness | The completeness and the associated accuracy of following the tasks on the e-booking prototype. |
| Satisfaction | The score the participants rated to Language, Colour theme, Dark mode, Font size and Overall satisfaction. |
| Efficiency | How the participants consider the e-booking prototype is easy to learn and easy to remember. |
| Adaptation | Which feature/setting of Accessibility Helper would the participant adapt on their second visit. |

## 6.2 User Study Results

This section follows the four domain evaluation criteria discussed in user study design. The quantitative outcomes were analysed using SPSS.

### 6.2.1 Participant Characteristics

Sixteen responses were included in the data analysis stage. Participant characteristics are presented (see Table 2). The gender distribution for male and female participants was 7 to 9, and half of them were over 35-year-old. Four participants responded positively to having existing chronic health issues and did not correctly identify all the numbers in the vision tests in the questionnaire.

### 6.2.2 Effectiveness

The completeness of tasks was 100%, while the accuracy was 88% since two participants were initially uncertainty but after being given instructions by the first author, they completed the tasks. As for the unclickable places, a female participant aged 26-35 clicked the chatbox to apply "Accessibility Helper" rather than clicking the robot itself instead. This was likely because the robot view (Figure 6a) of "Accessibility Helper" was not a traditional mode of interaction such as a button (Figure 6b).

However, three participants over 56 highlighted the attractiveness of the Robot design of Accessibility Helper. The elderly were less likely to quickly identify the desired clickable elements of the web page if there were several selectors or buttons in distinctly presented places as they felt distracted by a web page designed with too many colours and long paragraphs. This was consistent with the findings from our preliminary survey.

From our survey responses, the third sample eHealth website had too much text on the web page (approximately a third of the screen) and was the least favourable design. 19.2% of people felt a degree of discomfort and fear; the second sample eHealth website was annoying as it contained too many entries (eight selectors simultaneously). Participants aged 18-25 could quickly determine the correct approach to primary navigation, side navigation and foot navigation. At the same time, the elderly preferred to look at primary navigation first regardless of the tasks and felt confused having more than two navigation bars on the same web page.

In our analysis of the existing eHealth web portals, only eight among the 44 objective eHealth portals observed offered language translation, even though eHealth recommendations are to provide local languages supported by pictures and universal icons (Wickramasinghe et al., 2006). This is because when people access an eHealth website, not in their mother language, they typically look at the intuitive icon and guess where it would navigate them.

We found that not all icons are able to convey the correct meanings, for example, flat design icons lose most of the shadow and shape of content to simplify the design but confuse its meaning, especially for non-active online users. We showed two buttons designed in icon only (Figure 1b) in the preliminary survey to two participants aged over 65 and asked them to guess what the buttons were for. Not surprisingly, one non-active online user considered the "Listen" button as a "Light" button by which he could increase the lightness of the tool, and he had no idea what the "Print" button was. Another daily active user in a similar age considered the "Listen" button as a "Speaker" which was close to the proposed meaning but felt confused by the "Print" button as to whether it meant "Next page" or "Download". In this case, without any context near the icon, skeuomorphism design seemed to be a better alternative compared to a flat

Table 2: Participant characteristics of the user study.

| | Gender | Age group[6] | Main Language | Chronic health issues[7] | Visual impairment[8] |
|---|---|---|---|---|---|
| P1 | Male | 26 – 35 | English | Unsure | No |
| P2 | Female | 18 – 25 | Chinese | No | No |
| P3 | Male | 18 – 25 | English | No | No |
| P4 | Female | 26 – 35 | Chinese | No | No |
| P5 | Female | 26 – 35 | English | Unsure | No |
| P6 | Male | 46 – 55 | Chinese | Yes | Yes |
| P7 | Female | 36 – 45 | Chinese | Yes | Yes |
| P8 | Female | 46 – 55 | Chinese | Unsure | Yes |
| P9 | Male | >65 | Chinese | Yes | Yes |
| P10 | Female | 18 – 25 | Chinese | No | No |
| P11 | Male | 56 – 65 | Chinese | No | No |
| P12 | Female | 56 – 65 | Chinese | No | No |
| P13 | Female | 26 – 35 | English | No | No |
| P14 | Male | 18 – 25 | Chinese | No | No |
| P15 | Female | >65 | Chinese | Yes | Yes |
| P16 | Male | >65 | Chinese | Unsure | No |

design especially for elderly users.

#### 6.2.3 Satisfaction

No negative feedback on “Accessibility Helper” was revealed from all the user studies and overall, all participants were satisfied with the Accessibility Helper. Our analysis showed that Language was the feature people were most satisfied with, with a score of 4.8/5, followed by Font size 4.4/5, Colour theme 3.7/5, and Dark mode which was the lowest at 1.9/5. Most participants, regardless of age and gender, were pleased to access an eHealth web portal with the personalised setting “Accessibility Helper” rating 93.8% satisfaction (see Figure 7).

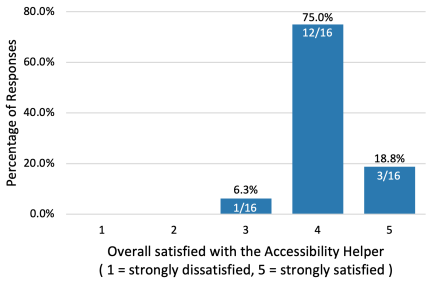



Figure 7: Distribution of participant agreement with the prompt “Overall, I am satisfied with the Accessibility Helper”.

[6]Participants were asked to identify their age in a range rather than specific chronological age.

[7]Chronic health issues were self-reported by the participant himself/herself, we did not go into detail for specific health issues if they answered positively to this question.

[8]Visual impairment was evaluated by whether or not the participant could correctly identify all the numbers in the colour blindness test in the questionnaire.

#### 6.2.4 Efficiency

We found that 81.3% participants considered booking appointments on the eHealth prototype is easy to learn (see Figure 8) and same percentage of those who considered it easy to remember (see Figure 9). However, the proportion of ”strongly agree” in easy to remember (50%) is larger than those proportion of ”strongly agree” in easy to learn (6.3%).

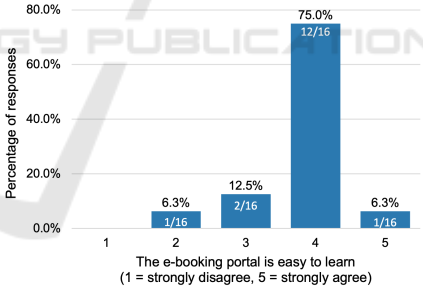



Figure 8: Distribution of participant agreement with the prompt “I consider this e-booking portal is easy to learn with the Accessibility Helper”.

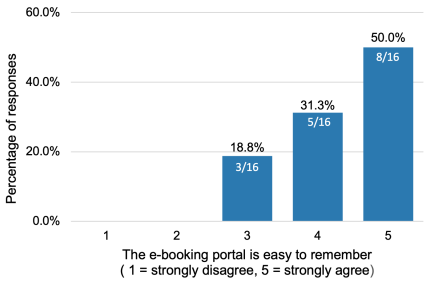



Figure 9: Distribution of participant agreement with the prompt “I consider this e-booking portal is easy to remember with the Accessibility Helper”.

The Participants over 65 preferred a software that was easy to learn rather than a fancy design software but difficult to figure out. They were more likely to feel less patient and struggled more when completing the user study. For instance, a participant aged 81 mentioned that he barely used Internet-based facilities, and as for seeing a doctor, he would generally go to the clinic in the rural area and wait for an on-site appointment. The benefit of saving time by using online appointment system did not attract older people since they were not as time pressured when seeing a doctor in a non-emergency setting. He also mentioned that there were too many points where he had to press on the application which would make him hesitate to continue:

> *"The first step for e-booking was to enter a keyword of clinic or doctor, but I was bad at typing. Still, there are several 'Press' which I do not think I can perform correctly next time on my own.... I have plenty of time to waste.... I prefer a face-face appointment at the clinic from where I can ask the nurse for further instructions."* [P9]

He also pointed out that less click and entry would be a must for him to master the tool, which should be considered since a third of all web searches are invoked not by typed but by voice query in 2019 (Cambre et al., 2021). Although Voice Assistant was performed as a roughness of functionality in the prototype design, we could still see there was a huge need for voice assistance among the elderly through the user study. While the importance of voice interaction with Internet-based applications is obvious, a tiny fraction was estimated to be available in 2019 (Cambre et al., 2021). All participants over 65 used Voice Assistant during the tasks, and most of them mentioned that they usually need instructions when accessing eHealth web portals on their first use.

### 6.2.5 Adaptation

Studies have shown that the following common problems affect patients when using web-based scheduling: being unaware of the web-based appointment service; low penetration and distrust of the Internet; low computer skills; and the preference for verbal communication (Zhao et al., 2017). We explored which accessibility settings the participants preferred to apply for their subsequent access and found the features of importance to address for subsequent access were Language (13/16, 81.3%), Font size (10/16, 62.5%), Colour theme (4/16, 25%), Dark mode (1/16, 6.3%), although two participants preferred to keep the default setting unchanged (see Figure 10).

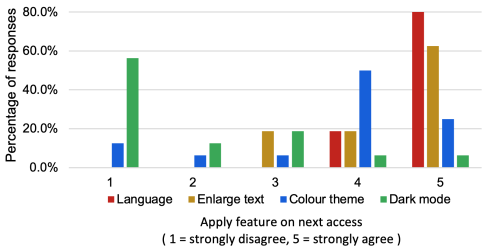



Figure 10: Distribution of participant agreement with the prompt "I would like to apply this feature on my next access to the eHealth web portals".

In order to rank each feature, we combined the ranking of the Satisfaction and Adaption domains. Interestingly, we found the ranking of all the features in the Adaptation domain were the same as those in Satisfaction, which from high to low were *Language*, *Enlarge text*, *Colour theme* and *Dark mode*. We discuss these in more detail below:

**Language -** Linguistic differences are one of the top priorities among human-centric aspects. Fourteen participants were not native English speakers, and therefore most of them thought *Language* was crucial since they were more likely to access eHealth websites in their mother language. One Chinese participant aged 26-35 living in Australia also emphasised the importance of the "Filter doctors by language" function in the prototype:

> *"My first appointment in Australia was with a non-Chinese speaking doctor. Before seeing her, I checked the terms like "symptom" and "penicillin" which I had a history of drug allergy, in case I did not understand the medical words.... Well, there were still some terms I did not catch, and I had to use onomatopoeia to express where I was in pain."* [P4]

She added that Language should be considered in eHealth web portals, even for people whose second language is English since they might not understand all the medical terms.

**Enlarge Text -** All elderly participants emphasised the necessity for enlarged text functionality. Usually, they would hold the phone close to their face if they could not see the font clearly on their phones but they cannot hold the desktop close to their eyes at home. They would be more likely to bow their upper body torso or straighten their neck to actively approach the computer screen to see the content more clearly. 57.1% elderly prefer to enlarge the text on the web page and thus they can see a larger font clearer with a relatively comfortable posture sitting on a chair.

**Colour Theme -** We should carefully consider the colour used on the eHealth website since people over 55 usually feel negative if the colour does not fit their preferences and colour insensitivity and poor eyesight are strongly correlated older age. For example, an 81 year old participant was only able to identify a red digit in the colour test, saying that the size of that digit was the largest even though the size of all the digits were the same while their contrast colour was not.

Similarly, four participants were not able to recognise a digit in light green colour possibly because they were not sensitive to light green with less contrast in background colour. Those four participants with poor visual impairment had different colour preferences. Half of them were resistant to the red colour while another half were in blue. It also shows that those with poor vision or colour blindness demonstrate a more substantial interest in Colour theme than other users.

Interestingly, most users preferred cool colours, which was consistent with the results from the preliminary survey (participants who preferred cool and warm colours were 53% and 39%, respectively). This may because participants who preferred the red colour theme were all from China. This may well be a cultural association as Chinese people, especially the elderly with traditional beliefs, consider red as positive (e.g. luck, marriage and new year) while others with negative feelings (i.e. anger). These colour–emotion associations are highly likely to be reinforced by the culture, given that red is the primary colour of its national flag (Jonauskaite et al., 2020). In the same vein, red clothing was highly regarded as the hierarchy of nobles in ancient times. Even after thousands of years, this colour has penetrated the Chinese consciousness and subconsciousness to affect their feelings and reactions (Ying and Xiaohong, 2020).

**Dark Mode -** Among all the features, Dark mode was the setting with the greatest differentiation among all the participants. Participants over 65, especially those with colour cognitive impairment, felt rejected when seeing a website containing a much darker colour. As per her comment:

> *"I do not like this dark design. I feel unhappy to seek health information. It will leave a bad impression the first time I see a web in a mostly dark colour. I will change to a lighter colour to suit my taste through "Accessibility Helper."* [P15]

Instead, participants aged 18-25 thought it was cool-looking and reduced visual fatigue in low-light environments when using online tools for a long duration (Erickson et al., 2021), especially for computer graphics artists and software programmers.

# 7 DISCUSSION

## 7.1 Key Findings

The findings of this study suggest that age and language are the top priorities among human-centric aspects to consider when designing eHealth web portals. Other human-centric aspects, such as gender, occupation, health condition, and culture, should also be considered. From the preliminary survey, the design efforts in the eHealth prototype, and user studies we conducted, it is obvious that the design elements were different depending on the users' age groups and/or their visual impairment. Their preferences should be a consideration when designing a more human-centric tool.

Although there was no statistical significance in the preference of the colour of the web page, most participants' emotions were demonstrated to be affected by the colour. They expressed negative feelings about the inappropriate colour used on the web application and positive emotions about being willing to access the websites if the colours were in their taste. people over 55 reported similar accessibility issues as 65 and despite not being in the 'elderly' category, they still need their human aspects to be considered when developing software, especially since visual impairment post 55 is almost universal.

The user studies to evaluate our e-booking web-portal with the "Accessibility Helper" option revealed that evaluating eHealth web portals to satisfy diverse users and accommodate their needs using a prototype is vital to improving the user experience. An in-built all-in-one Accessibility Helper could provide different users with all the features designed in human-centric aspects anticipated. A prototype allows users to have a more intuitive experience before and after applying different features, and the 'Think-Aloud' approach is a sound method for capturing their feelings and responses appropriately.

## 7.2 Limitations

Limited sample size, and not including sufficient older adults aged over 65 from diverse backgrounds, are potential limitations for this research. These groups are less likely to access the Internet as frequently as the people in their 20s. Online recruitment was difficult, especially for the late-elderly (75

and older), and the restrictions of conducting face-to-face user studies were restricted during the COVID-19 pandemic. We did not include people less than 18 in our participant groups for ethical reasons, and therefore their needs for eHealth web portals were not included.

The lack of detail in the preliminary survey about the specific chronic health conditions people reported means our results are not generalisable for all chronic health issues. Similarly, only four vision tests for colour-blind or visual impairment are insufficient to diagnose all visual impairment which might bias the results leading to colour-blind people considering the Colour theme as the top priority or short-sighted people choosing Enlarge text as the main priority.

The race distribution of the elderly was skewed to Chinese participants and potentially led to bias. This result in the fact that most elderly preferred red colour as the main colour tones of a eHealth web portal becuase of the culture and colour–emotion associations.

### 7.3 Future Work

This research principally analysed fundamental demographics like age, gender and cognitive impairment. Wider demographic area, including more different languages, more respondents, especially elder ones with a higher participation of chronic problems, will be our future direction. This research did not involve other human-centric issues such as personality, education, and users with special needs. Also, the prototype involved a robot design of "Accessibility Helper" without a skeuomorphism button designed for the evaluation, which we will take into account in our future work. In the future research, we will also analyse whether such a human-centric eHealth web portal is applicable to target users and actual patient data.

## 8 CONCLUSION

This research investigated human-centric issues in eHealth web applications. We conducted a preliminary survey and designed a prototype which we evaluated with 16 user studies. The study suggests that age and language are two contributing factors to consider when developing a human-centric eHealth web portal. Different colours for the web page are mostly preferred based on users' visual status and their perceptions of that colour by personal taste and culture. The most compelling evidence could be that traditional Chinese elderly prefer red colour and feel discomfort with mostly dark colours, while the younger generation aged 18-25 are more likely to use darker design (i.e. dark mode).

The majority of survey results and user studies indicate that icon and text buttons could be the best way to navigate web pages where "icon only" appears to be a poor design practice, especially for non-active online elderly users. For most elderly participants, skeuomorphism is more comprehensive instead of flat design. Similarly, preventing excessive entries and clicks as well as reducing redundant paragraphs on the same page could increase efficiency and effectiveness, particularly for the elderly to approach the eHealth applications by themselves. Not surprisingly, enlarging font size seems to be a necessary setting for poor eyesight regardless of age and gender. To emphasise, an all-built-in-one "Accessibility Helper" is sufficiently important for different users when accessing the eHealth web portal. Such a helper could consider more human-centric issues and, as a result, increase adaptation of the eHealth applications and support health information widely accessible for diverse user groups.

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## REFERENCES

Akerkar, S. M. and Bichile, L. S. (2004). Doctor patient relationship: changing dynamics in the information age. *J. Postgrad. Med.*, 50(2):120–122.

Ancker, J. S., Barrón, Y., Rockoff, M. L., Hauser, D., Pichardo, M., Szerencsy, A., and Calman, N. (2011). Use of an electronic patient portal among disadvantaged populations. *J. Gen. Intern. Med.*, 26(10):1117–1123.

Au, A. M. L., Chan, S. C. Y., Yip, H. M., Kwok, J. Y. C., Lai, K. Y., Leung, K. M., Lee, A. L. F., Lai, D. W. L., Tsien, T., and Lai, S. M. K. (2017). Age-friendliness and life satisfaction of young-old and old-old in hong kong. *Curr. Gerontol. Geriatr. Res.*, 2017:6215917.

Boulos, M. N. K. (2003). The use of interactive graphical maps for browsing medical/health internet information resources. *Int. J. Health Geogr.*, 2(1):1.

Bradshaw, P., Pellicano, E., van Driel, M., and Urbanowicz, A. (2019). How can we support the healthcare needs of autistic adults without intellectual disability? *Curr. Dev. Disord. Rep.*, 6(2):45–56.

Cambre, J., Williams, A. C., Razi, A., Bicking, I., Wallin, A., Tsai, J., Kulkarni, C., and Kaye, J. (2021). Firefox voice: An open and extensible voice assistant built

upon the web. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, New York, NY, USA. ACM.

Das, A., Faxvaag, A., and Svanæs, D. (2015). The impact of an ehealth portal on health care professionals' interaction with patients: Qualitative study. *J. Med. Internet Res.*, 17(11):e267.

Eccles, D. W. and Arsal, G. (2017). The think aloud method: what is it and how do I use it? *Qual. Res. Sport Exerc. Health*, 9(4):514–531.

Erickson, A., Kim, K., Lambert, A., Bruder, G., Browne, M. P., and Welch, G. F. (2021). An extended analysis on the benefits of dark mode user interfaces in optical see-through head-mounted displays. *ACM Trans. Appl. Percept.*, 18(3):1–22.

Ferreira, J. M., Acuña, S. T., Dieste, O., Vegas, S., Santos, A., Rodríguez, F., and Juristo, N. (2020). Impact of usability mechanisms: An experiment on efficiency, effectiveness and user satisfaction. *Inf. Softw. Technol.*, 117(106195):106195.

Goel, M. S., Brown, T. L., Williams, A., Hasnain-Wynia, R., Thompson, J. A., and Baker, D. W. (2011). Disparities in enrollment and use of an electronic patient portal. *J. Gen. Intern. Med.*, 26(10):1112–1116.

Góngora Alonso, S., Toribio Guzmán, J. M., Sainz de Abajo, B., Muñoz Sánchez, J. L., Martín, M. F., and de la Torre Díez, I. (2020). Usability evaluation of the ehealth long lasting memories program in spanish elderly people. *Health Informatics J.*, 26(3):1728–1741.

Gordon, N. P. and Hornbrook, M. C. (2018). Older adults' readiness to engage with ehealth patient education and self-care resources: a cross-sectional survey. *BMC Health Serv. Res.*, 18(1).

Grundy, J., Khalajzadeh, H., and Mcintosh, J. (2020). Towards human-centric model-driven software engineering. In *Proceedings of the 15th International Conference on Evaluation of Novel Approaches to Software Engineering*. SCITEPRESS - Science and Technology Publications.

Isa, W. A. R. W. M., Suhaimi, A. I. H., Ariffrn, N., Ishak, N. F., and Ralim, N. M. (2016). Accessibility evaluation using web content accessibility guidelines (wcag) 2. 0. In *International Conference on User Science and Engineering (i-USEr)*, pages 1–4. IEEE.

Jonauskaite, D., Parraga, C. A., Quiblier, M., and Mohr, C. (2020). Feeling blue or seeing red? similar patterns of emotion associations with colour patches and colour terms. *Iperception*, 11(1):2041669520902484.

Kotronis, C., Routis, I., Politi, E., Nikolaidou, M., Dimitrakopoulos, G., Anagnostopoulos, D., Amira, A., Bensaali, F., and Djelouat, H. (2019). Evaluating internet of medical things (IoMT)-based systems from a human-centric perspective. *Internet of Things*, 8(100125):100125.

Maramba, I., Chatterjee, A., and Newman, C. (2019). Methods of usability testing in the development of ehealth applications: A scoping review. *Int. J. Med. Inform.*, 126:95–104.

Oh, H., Rizo, C., Enkin, M., and Jadad, A. (2005). What is ehealth?: a systematic review of published definitions. *World Hosp. Health Serv.*, 41(1):32–40.

Paré, G., Trudel, M. C., and Forget, P. (2014). adaption, use, and impact of e-booking in private medical practices: mixed-methods evaluation of a two-year showcase project in canada. *JMIR medical informatics*, 2(2):3669.

Schnipper, J. L., Gandhi, T. K., Wald, J. S., Grant, R. W., Poon, E. G., Volk, L. A., Businger, A., Siteman, E., Buckel, L., and Middleton, B. (2008). Design and implementation of a web-based patient portal linked to an electronic health record designed to improve medication safety: the patient gateway medications module. *Inform. Prim. Care*, 16(2):147–155.

Shamsujjoha, M., Grundy, J., Li, L., Khalajzadeh, H., and Lu, Q. (2021). Human-centric issues in ehealth app development and usage: A preliminary assessment. In *2021 IEEE International Conference on Software Analysis, Evolution and Reengineering (SANER)*. IEEE.

Smail-Crevier, R., Powers, G., Noel, C., and Wang, J. (2019). Health-related internet usage and design feature preference for e-mental health programs among men and women. *J. Med. Internet Res.*, 21(3):e11224.

Van Gemert-Pijnen, J. E. W. C., Peters, O., and C, H. (2013). Improving ehealth.

Venkatesh, V. and Morris, M. G. (2000). Why don't men ever stop to ask for directions? gender, social influence, and their role in technology acceptance and usage behavior. *MIS Q*, 24(1):115.

Wickramasinghe, N., Geisler, E., and Schaffer, J. (2006). Assessing E-Health. In *E-Health Systems Diffusion and Use*, pages 294–323. IGI Global.

Ying, Q. and Xiaohong, Z. (2020). Research on the colour culture of red in chinese traditional costume. *JOURNAL OF THE COLOR SCIENCE ASSOCIATION OF JAPAN*, 44(3+):186.

Zhao, P., Yoo, I., Lavoie, J., Lavoie, B. J., and Simoes, E. (2017). Web-based medical appointment systems: A systematic review. *J. Med. Internet Res.*, 19(4):e134.