Persuasive Design of a Mobile Application for Reducing Overcrowding in Saudi Hospital Emergency Departments

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Abstract. Overcrowding in emergency departments (EDs) is a critical issue in health sectors worldwide. In Saudi Arabia, EDs experience this issue because many patients visit EDs seeking treatment even for a non-emergency health condition. Therefore, in this study, we present and test a solution to help reduce ED overcrowding in Saudi Arabia—a mobile application that we developed using persuasive design principles. The main aims of the application are to discourage patients with non-emergency conditions from arriving at EDs and, if they have already arrived, to manage and encourage them to transfer to primary healthcare centers (PHCs) or less-crowded EDs. The application is framed by eight main design principles (social proof, scarcity, authority, modernity, time-saving, empathy, transparency, and awareness). We tested the application based on a set of role-play evaluation scenarios through a user study with 89 participants. The overall result showed that the application successfully encouraged 73.7% of participants to visit PHCs instead of EDs, discouraged 55.3% from visiting overcrowded EDs, and encouraged 68.4% to transfer from overcrowded EDs to other health centers. Design aspects related to the time-saving and empathy principles were the factors that most influenced participants' decisions. Overall, our application that incorporates design principles can facilitate tackling the ED overcrowding issue, given that it successfully influenced more than half of the participants. Further, this study has implications for both the human–computer interaction and the health informatics communities because it employs a mobile software solution with design principles to tackle a critical universal issue that affects healthcare quality and patients' satisfaction.

Keywords: Persuasive design · Overcrowding · Emergency departments · Saudi Arabia

1 Introduction

The overcrowding of emergency departments (EDs) is defined as "the situation in which ED function is impeded primarily because of the excessive number of

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patients waiting to be seen, undergoing assessment and treatment, or waiting for departure comparing to the physical or staffing capacity of the ED." [29]. Over the past few decades, the number of patients visiting EDs has increased substantially [7,9–12,16,18,21–23]. This situation has led to ED overcrowding becoming a critical issue in many countries [13]. In fact, some countries have identified ED overcrowding as a national crisis [18].

As a major public health problem, ED overcrowding leads to multiple negative consequences, including long waits for diagnosis and treatment, delays in treating seriously ill patients, increased costs owing to unnecessary diagnostic investigations, decreased physician productivity, frustration among medical staff, and patient dissatisfaction [10,14].

In this regard, EDs in Saudi Arabia are overcrowded because of non-urgent visits. A study published in 2020 highlighted that 78.5% of the visits to an ED in a tertiary care center in Saudi Arabia were for non-life-threatening conditions [1]. In 2012, Bakarman et al. [2] used the Canadian Triage and Acuity Scale (CTAS) to assess the emergency levels of ED visits by a sample of patients who attended the ED of King Fahd Hospital, a major hospital in Jeddah city. They found that 65% of the visits were for non-emergency conditions (CTAS IV and V) and that among all ED visits, less than 10% of the patients needed immediate (CTAS I) or emergency care (CTAS II). An earlier study, published in 2002, reported similar results about the percentage of non-emergency cases at a community hospital ED in Saudi Arabia [24]. Further, it was estimated that across the country, EDs received 21.2 million patients in 2015 and that 60% of the cases were non-emergency cases [27]. Similar results were reported for other countries, such as the United States [4] and the United Kingdom [6].

Many factors are associated with non-urgent ED visits. For instance, a study on the United States reported that the younger age of patients, the accessibility of the ED compared with other options, referrals to the ED, and negative perceptions about alternatives such as primary healthcare services were associated with non-urgent ED visits [28]. In Turkey, the reasons for non-urgent ED visits were the need to refill medications, request painkillers, and treat upper respiratory tract infections, as well as the lack of understanding about who should visit an ED and benefit from its services [25]. In South Africa, the reasons for non-urgent ED visits were the lack of benefit from outpatient clinics, the perception that EDs offer better treatment, and the unavailability of PHCs over 24 h [3]. In Saudi Arabia, the main causes for ED visits were the patients' perception that their condition needed urgent medical attention, the ease of access to EDs, and the limited resources and services at PHCs [1]. A study on three Saudi Arabian hospitals found that a significantly high proportion of patients with non-urgent conditions did not attempt to visit PHCs before their ED visits and that patients believe that the ED is the first place to visit in case of illness [8].

Generally, technology and design are less employed to solve ED overcrowding. Since ED overcrowding has been highlighted as a key national challenge, Saudi Arabia has encouraged the innovation of digital solutions to solve this issue [27]. Therefore, to partially contribute to solving this problem, we introduced

a mobile software solution with a set of design principles to help discourage patients with non-emergency health conditions from visiting overcrowded EDs and to encourage them to visit PHCs. In this study, we present the mobile software solution, which we named Saleem (an Arabic term for referring to a person who is free from a health issue or at a satisfactory state), and report the results on testing this solution with a group of intended users.

In Sect. 2, we present the mobile application solution and the applied design principles. In Sect. 3, we present the user study method, followed by the results in Sect. 4, and last, the discussion and conclusion in Sect. 5.

2 Designing the Mobile Application

Our application targets two groups of patients, those who have already arrived at EDs and those who have not. The application aims to manage the first group and to encourage those with non-emergency conditions to transit to PHCs or less-crowded EDs. Further, as regards the second group, the application aims to discourage those with non-emergency conditions from visiting EDs (see Fig. 1).

Persuasive design principles are commonly used in different technology domains (see [15,17,19,20,26]) and have been proved to be effective. Therefore, we reviewed the literature and identified a set of persuasive design principles (e.g., social proof) that can be employed in the application to help achieve its goals. We also brainstormed regarding other design principles (e.g., empathy) that can also help achieve the application goals. Figure 1 illustrates the objectives of our mobile application and the design principles applied to it.

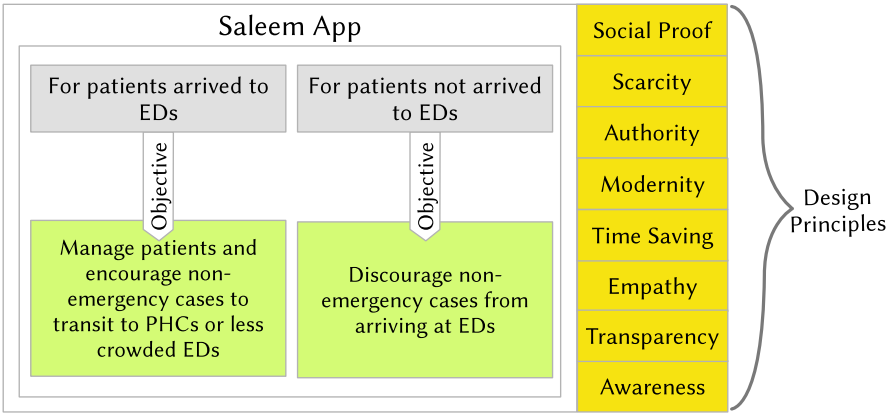

Fig. 1. Saleem application objectives and design principles.

Figure 2, 3, and 4 shows examples of the Arabic interfaces of the application. Figure 2 illustrates a PHC interface and highlights the design principles used to encourage PHC visits. Figure 3 illustrates an ED interface and the design

principles used to discourage patients from visiting an overcrowded ED and encourage them to visit PHCs or less-crowded EDs (for patients who have not arrived). Figure 4 shows the ED patient management interface and the design principles applied to the interface to encourage patients with non-emergency conditions to transit from an overcrowded ED to PHCs or less-crowded EDs (for patients who have arrived). The design principles applied to the interfaces are explained in the following subsections.

2.1 Social Proof

If uncertain about something, people usually take cues from others and imitate each other [5]. In interface design, social proof can be represented by providing evidence of other user actions to influence the current user's decision to repeat the same actions. For example, hotel-booking applications show prior customers' rankings and reviews of a hotel to influence the potential users' decisions about booking room(s) in the hotel. The same principle is used in e-commerce: Online shops display the customer recommendations and positive reviews about their products to influence others to buy them. In our mobile application, we employed the social proof principle to encourage patients with non-emergency conditions to visit PHCs (i.e., by displaying patients' rating of PHCs, as shown in Fig. 2b).

2.2 Scarcity

The sense of losing opportunity can significantly influence human decision-making [5]. In the online context, scarcity is used widely across different domains. For example, e-commerce services use phrases such as "available for limited time" or "only two rooms/seats left" when showing offers to users, which can trigger or initiate users to act fast. In our application, we used sentences such as "If you arrive at the PHC within the next 30 min, the waiting time will not exceed 15 min," as shown in Arabic text in Fig. 2c, Fig. 3b, and Fig. 4e, to give them the feeling that the opportunity of a short wait to diagnosis and treatment can be lost if they did not act fast without procrastinating.

2.3 Authority

Information from an authority (e.g., a government organization) can influence decisions on how to act in a particular situation [5]. We expected that providing information in our application from a health authority about PHCs can encourage patients to visit these centers. Hence, we showed such information (five-star quality rating of PHCs in Fig. 2a), indicating that a health authority was its source, to encourage people to visit PHCs. The information was not real and was used for the purpose of evaluating the impact of this design principle on people's decision to visit PHCs.

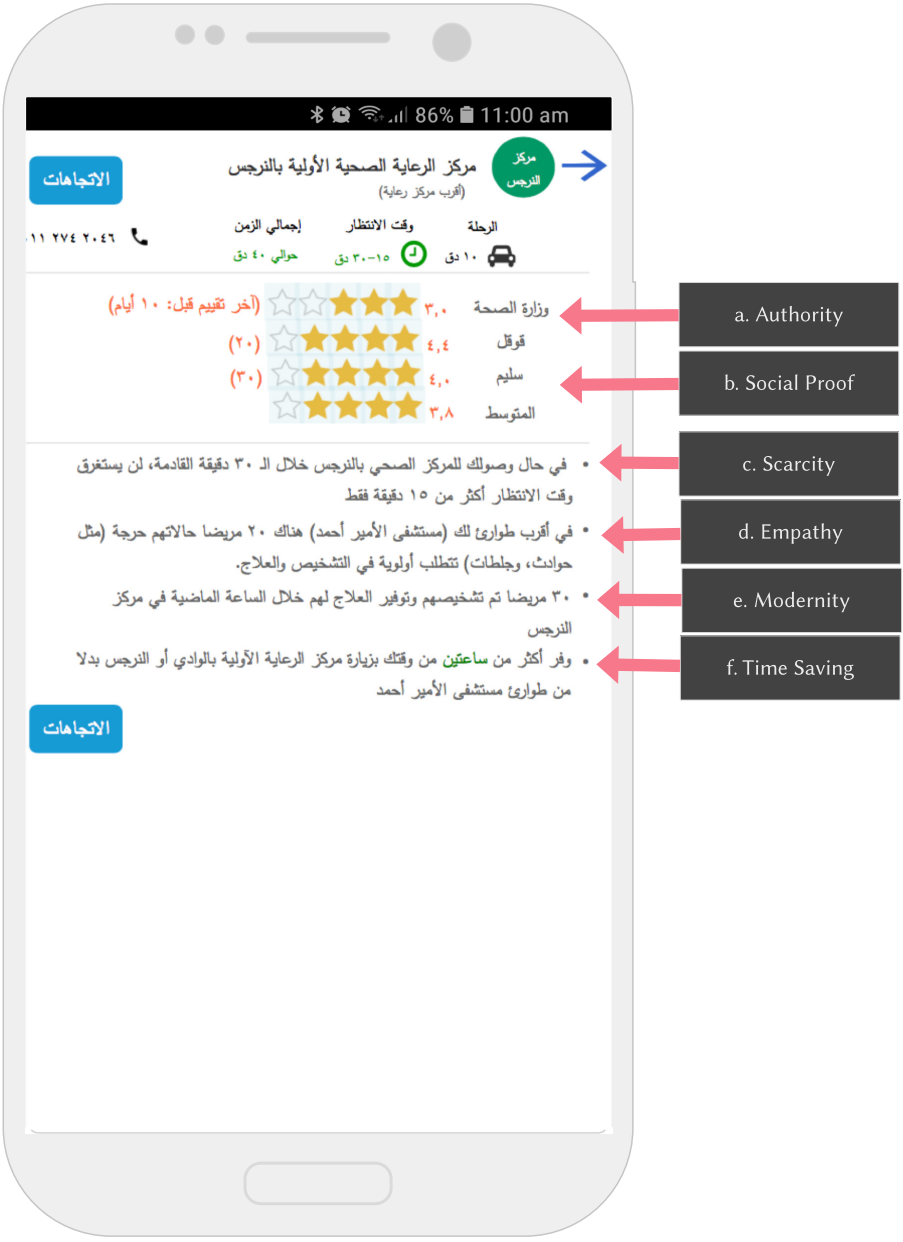

Fig. 2. A PHC interface.

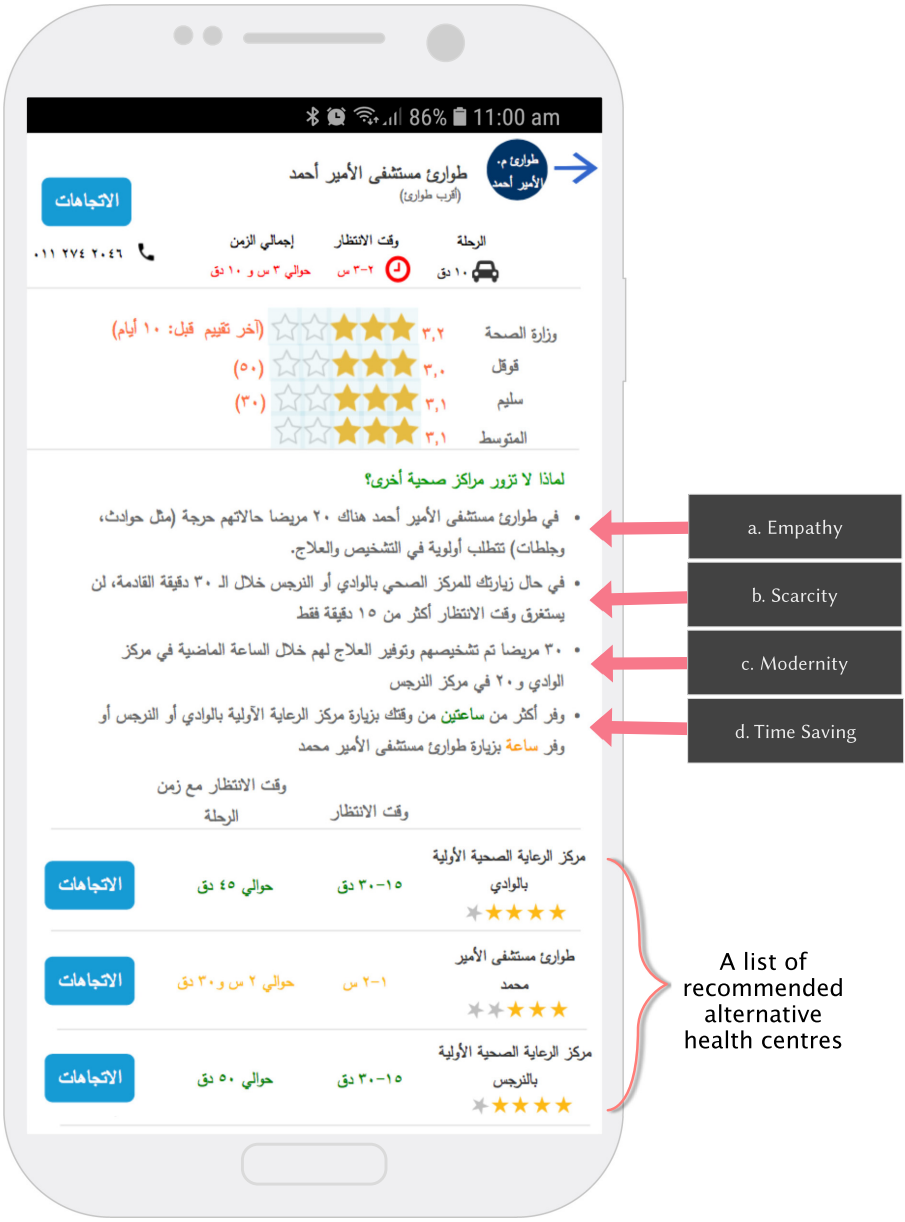

Fig. 3. An ED interfaces.

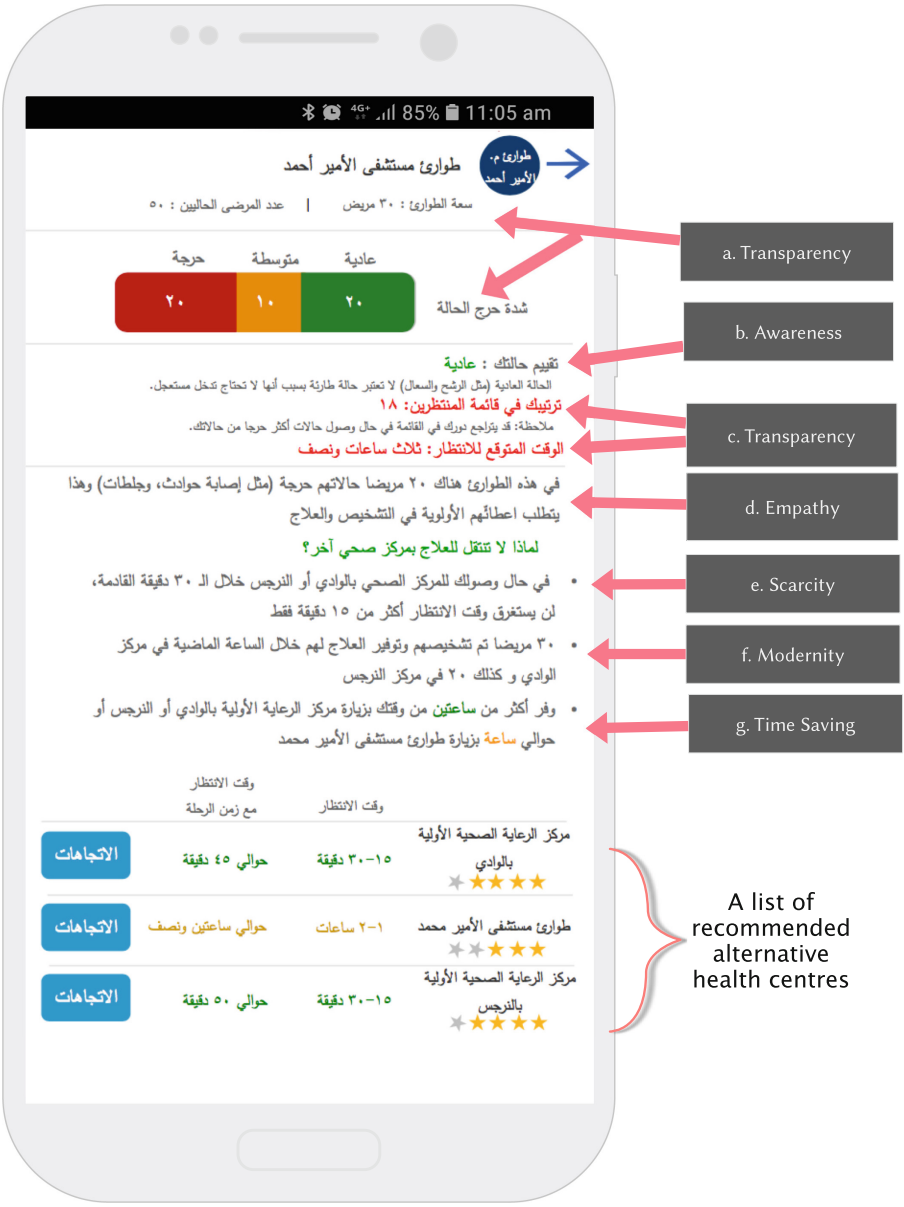

Fig. 4. An ED interface.

2.4 Modernity

The modernity principle has also been used widely in interface design to encourage people to behave in a certain way. For instance, some online services show recent users' actions to motivate other users to perform the same actions. Some hotel-booking websites show data on recent room bookings, such as "latest booking of this kind of room: 30 s ago." In our mobile application, to encourage people to visit PHCs, we used a similar technique by showing phrases such as "In the past hour, 30 patients were diagnosed and received treatment at this center," as shown in Arabic in Fig. 2e, Fig. 3c, and Fig. 4f.

2.5 Empathy, Transparency and Awareness

We also employed the empathy principle. For example, we used phrases to show the numbers and examples of critical cases in the EDs and the priorities for these cases to receive treatment (Fig. 2d, Fig. 3a, and Fig. 4d). We followed this approach to induce patients with non-emergency conditions to empathize with patients with critical conditions. The aim was to motivate the former group to decide to visit PHCs or to transfer from EDs to PHCs to allow the ED medical staff to spend more time with the critically ill patients and hence provide them better care.

We also showed content to improve transparency (e.g., "The capacity of the ED is 30, and the number of current patients is 50"; see Fig. 4a), to encourage patients with non-critical conditions to transfer to PHCs or to less-crowded EDs.

The application was also designed to raise patients' awareness of what is considered an emergency case through using phrases such as "Normal cases, such as a cold, are not considered emergency cases, and they do not need immediate intervention" (see Fig. 4b). One purpose of these phrases was to let patients feel less stressed about their health condition and to visit or transfer to PHCs instead of visiting EDs.

3 Method

3.1 Recruitment, Participants, and Data Collection

We recruited study participants through social media groups. We targeted social media groups in two different regions of Saudi Arabia that have different healthcare quality levels. In all, 89 participants (30 female) evaluated our mobile application. They were from different age groups and had various qualifications (see Table 1). They were given a set of evaluation scenarios and instructed to interact with specific interfaces of the mobile application. Then, they were asked to complete a questionnaire with a set of close-ended and Likert questions related to each scenario. We followed the ethical guidelines for research in Saudi Arabia.

Table 1. Age and qualification of participants.

Age	No. of participants	Highest qualifications	No. of participants
≤20	3	High school or less	27
21–29	52	Diploma	9
30–39	28	Bachelor's degree	49
40–49	6	Master's degree	4

3.2 Evaluation Scenarios

In this study, we tested the mobile application based on three main evaluation scenarios.

In Scenario 1, we instructed the participants to assume that they aimed to visit an ED but that before visiting the ED, they need to interact with a specific PHC interface in the mobile application (Fig. 2). We used this scenario to test whether the applied design principles could influence their decision by changing their original aim of visiting the ED to visiting the PHC instead.

In Scenario 2, we instructed the participants to assume that they aimed to visit an ED but that before visiting this ED, they need to interact with the ED page in the application (Fig. 3). We used this scenario to test whether the design discourages users from visiting the ED and encourages them to visit other health centers, and to assess whether the design principles employed in the ED interface had influenced their decision to visit other health centers and to change their original plan of visiting the ED.

In Scenario 3, we instructed the participants to assume that they had already arrived at an ED, that their condition was assessed as a non-emergency, and that while awaiting treatment, they need to use the patient management page for the ED (Fig. 4). We used this scenario to test whether the design encourages participants to transfer from an overcrowded ED to other health centers, and to assess whether the design principles employed in the ED patient management page could influence their decision to transfer from the current ED to other health centers.

4 Results

The results for the first evaluation scenario showed that the design succeeded in encouraging 73.7% of the participants to change their plan from visiting the ED to visiting a PHC presented to them in the scenario. The results also showed that the design principles applied to the PHC interface influenced many participants to make this decision. According to the questionnaire responses, the percentage of participants influenced by the design aspects related to social proof was 68.18%, to scarcity was 72.30%, to authority was 71.6%, to modernity was 63.49%, to time-saving was 73.84%, and to empathy was 76.92%.

The results for the second scenario showed that the design contributed to discouraging 55.3% of the participants from visiting the ED and changing their plan to visit a PHC. In addition, the design principles used in the ED interface influenced many participants to make this decision. That is, 61.53% of them were influenced by scarcity, 64.15% by modernity, 71.69% by time-saving, and 72.54% by empathy.

The results for the third scenario showed that the design succeeded in encouraging 68.4% of the participants to transfer from the overcrowded ED to other health centers. Our analysis of the results also showed that the design principles used in the third scenario influenced these decisions as follows: 86.79% of the participants were influenced by scarcity, 69.64% by modernity, 81.81% by time-saving, 83.01% by empathy, 73.21% by transparency, and 73.68% by awareness.

The design aspects related to each design principle were rated on a 7-point Likert scale ranging from 1 ("not at all important") to 7 ("extremely important"), in terms of how important the aspect was when deciding to visit or not visit a healthcare center. For the first scenario, waiting time, which is related to the time-saving principle, and the text used for the empathy principle were the two most influential design aspects, scoring an average of 5.59 (SD = 1.63) and 5.56 (SD = 1.92) on the scale, respectively. For the second scenario, the text used for empathy (M = 5.40, SD = 1.92) and the explicit text indicating the time to be saved by visiting a PHC instead of an ED (M = 5.39, SD = 1.94) were the two most influential design aspects. For the third scenario, two design aspects, waiting time (M = 5.64, SD = 1.72) and the text indicating the time to be saved by transferring to other healthcare centers (M = 5.61, SD = 1.75), both of which are related to the time-saving principle, were the most influential.

5 Discussion and Conclusion

This study contributed design principles that can be employed in software solutions for tackling the ED overcrowding problem in Saudi Arabia. It also presented the evaluation results of a mobile software solution that employs these design principles to reduce ED overcrowding. The overall result in relation to the objectives of this application showed that it was successful in encouraging many participants to visit PHCs as well as in discouraging many from visiting EDs. The results also showed that all design principles influenced the decision of many participants as follows: to visit PHCs instead of an ED in the first evaluation scenario, to not visit an ED in the second scenario, and to transfer from an overcrowded ED to other centers in the third scenario.

Regardless, this study has some limitations. One is that it is based on role-play scenarios, and participants had been in situations described in the scenarios. Their decisions could differ in real situations when the application is tested "in the wild," given the sensitivity of the situations involved, where people may be fearful for their life. In this case, their behavior is bound to be radically different, which would thus invalidate the presented findings. Hence, we aim to confirm our findings through testing the application with patients in real situations.

The second limitation is that the study involved many variables, making it difficult to establish whether participants were able to remember and report accurately all variables that affected their decisions. Hence, our future studies will involve groups where we will apply only specific design principles to the application, so that we can compare the results for the groups. We intend to design several versions of the application, each with its own design principles, to further confirm the impact of each design principle and to triangulate this study's findings and those of future experiments.

The third limitation is that the study participants were mainly from only two areas in Saudi Arabia. The underlying reasons for the ED overcrowding problem can vary between regions (e.g., a lack of investment in healthcare facilities or the poor distribution of resources in specific regions). Hence, the overcrowding problem in each region must diagnosed before generalizing a solution across different regions.

Last, although the study provided some indications about the potential role of persuasive technology in solving the ED overcrowding problem, it is risky to draw policy decisions based on the experiences of a small number of patients in specific contexts. That is, the number of participants in our study is small considering the large population targeted by the software solution. Therefore, it is necessary to conduct further studies using large samples.

Nevertheless, overall, this study represents the initial step toward employing persuasive technology to tackle ED overcrowding and would encourage further research on this topic.

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