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Designing and Evaluating a Mobile-based Self-care Application for Patients with Gastrointestinal Cancer to Manage Chemotherapy Side Effects

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Abstract

Background: Controlling and managing the side effects of chemotherapy is one of the most serious challenges that patients with gastrointestinal cancer encounter. A promising technique to overcome these challenges is using informative mobile-based applications. The aim of this study was to design and evaluate a mobile-based application to help patients with gastrointestinal cancer to manage the possible side effects caused by chemotherapy.

Methods: This descriptive-applied study was performed in 2 stages. In the first stage, a needs assessment was performed where the opinions of 4 oncologists and 27 patients with gastrointestinal cancer were obtained by use of a researcher-designed questionnaire. In the second stage of the study, based on the identified needs from the first stage, an application prototype was designed and later evaluated. Participants were asked to use the application for 1 week to evaluate the usability of the application. The Questionnaire for User Interaction Satisfaction Version 5.5 was used for evaluation. The results of the study were analyzed using descriptive statistics and SPSS software Version 22.

Results: Of the 34 data elements obtained in the first step, 30 gained a mean above 3.75 and were considered in designing the application. The following features were included in the application: demographic data, history, clinical data, managing psychological and psychiatric challenges, lifestyle information, management of side effects, communication possibility, and other application features. Also, the evaluation results showed that the users gave a mean of 7.12 to the application and believed its usability was good.

Conclusion: This application and its capabilities can help patients with gastrointestinal cancer undergoing chemotherapy to better perform self-care processes, improve their health status, and reduce the side effects of chemotherapy.

Keywords: Gastrointestinal Neoplasm, Chemotherapy, Adverse Effects, Mobile Applications, Self-Care

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Introduction

After cardiovascular diseases, cancer is known to be the second leading cause of death worldwide (1). Cancer has drastically affected many societies and their economies (2). Yearly, more than 14 million people are diagnosed with cancer, and it is expect ed that this number will reach 22 million per year by the year 2030 (3). Gastrointestinal cancers account for more than a quarter (26%) of all global cancers and more than a third (35%) of all cancer deaths (4). Gastrointestinal cancer and its complications have affected peoples' social life, interpersonal and marital

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↑What is "already known" in this topic:
Mobile applications are one of the most useful ways of self-care to control and manage the side effects of chemotherapy in patients with gastrointestinal cancer.

→What this article adds:
The Tumorfight application can help improve the health of patients with gastrointestinal cancer and reduce the side effects of chemotherapy by providing a variety of self-care services.

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relationships, daily activities, and their occupations (5). Also, besides causing physical, mental, social, and economic issues for these patients, cancer has also brought complications to the lives of patients' families and their caregivers (6). Chemotherapy is one of the most effective methods that reduces the complications caused by cancer and helps in treating cancer patients. Depending on the progression of their disease, cancer patients undergo various treatments, such as chemotherapy, radiotherapy, and surgery (7).

The side effects of these treatments, especially those caused by chemotherapy, put patients at risk of other complications, such as fatigue, nausea, vomiting, diarrhea, weight loss, hair loss, skin problems, pain, sleeping disorders, and depression (8). One of the main reasons for observing an increase in these common complications is that those cancer patients who live in remote and rural areas usually have insufficient knowledge about the disease, are unaware of the treatment processes, and they do not have easy access to healthcare providers at any time and/or place that they require.

On the other hand, being far from medical centers increases the number of trips that cancer patients have to make to receive the healthcare services they need while it also elevates their costs, pain and discomfort, and the time they spend. Also, the lack of access to health information and healthcare providers leads to dissatisfying results in treatment, more mental illnesses, lower quality of life, and weak physical functioning in patients (9-11). Given these challenges, if cancer patients take part in their care and treatment process, they can overcome many of these challenges (12).

Self-care is defined to be a person's ability to perform health-related activities for self, such as tracking one's treatment progress, monitoring one's symptoms, evaluating one's treatment side effects and/or disease complications, having a healthy diet, exercising regularly, and finally improving one's general health (13, 14). Self-care processes help individuals to adapt to the chronic conditions of diseases, they leave a positive effect on one's quality of life, and ultimately they will also help reduce treatment costs (13, 15).

One of the methods that has become quite of an interest in cancer care is the use of mobile-based healthcare applications as this will also help to improve the effects and efficiency of these programs (16).

Mobile-based healthcare programs can play an important role in managing cancer and its possible complications, and providing care as well as post treatment care to patients (17). Efficient applications that can be offered through mobile-health (MH) can be used in disease prevention, diagnosis, management, treatment, and survival of cancer patients (18).

A number of studies have proven the promising role of MH in providing ongoing care to patients who have been receiving chemotherapy. Cheong et al have shown that MH programs, mobile phones, and other wearable devices will improve a patient's physical functioning, insomnia, fatigue, appetite, diarrhea, and vomiting, especially in patients who are suffering from gastrointestinal cancer and are undergoing chemotherapy (19). By designing and implementing a mobile-based game to improve self-management and reduce the side effects of chemotherapy, Kim et al showed that the use of mobile-based games and applications is a fundamental and effective way to improve chemotherapy outcomes (20).

Considering the high number of gastrointestinal cancer patients and the many challenges that they encounter, the aim of this study was to design and evaluate a mobile-based application that would help prevent, relieve, and reduce the side effects of chemotherapy for patients with gastrointestinal cancer (esophagus, abdomen, and intestine). To the researchers' best of knowledge, there has been no study conducted on designing and implementing a practical application that would help improve these cancer patients' state of health. Such an application can help prevent the worsening of chemotherapeutical side effects, reduce the number of in-person visits to healthcare institutions, save time for both physicians and patients, establish an effective communication among physicians, patients, and their families, and provide easy access to information that would help manage side effects.

Methods

This descriptive-applied study was conducted in 2 stages.

First Stage: Identifying the Educational-Informative Needs and Required Features for Designing the Application

In this stage, a researcher-designed needs assessment questionnaire was used to collect data. After related articles (21-26) and other designed applications (27-33) were reviewed, 9 sections were considered in designing the questionnaire of this study. The first section focused on collecting participants' demographic information (age, gender, marital status, and education). The other 8 sections (34 questions) included demographic data (6 questions), history (3 questions), clinical data (6 questions), managing psychological and psychiatric challenges (4 questions), lifestyle information (6 questions), management of side effects (3 questions), communication possibility (2 questions), and other application features (4 questions), respectively. The content validity of the questionnaire was confirmed by 2 medical informatics specialists, 2 health information management specialists, and 2 oncologists. Also, the reliability of the questionnaire was 0.95 based on the Cronbach alpha test.

In the first stage, the study population consisted of all oncologists and patients with gastrointestinal cancer who were undergoing chemotherapy at Javad'ol'aemme specialized clinic in Kerman (Iran). To participate in the study, an invitation was sent to all 9 oncologists and 56 patients with gastrointestinal cancer. Six oncologists and 30 patients consented to participate in the study. According to the following inclusion criteria, 27 patients and 4 oncologists were selected to participate in the study, respectively.

The Inclusion Criteria for Patients Were as Follows:

- Having intestinal, abdomen, or esophagus cancers
- Patients' willingness to participate in the study

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• History of at least 2 courses of chemotherapy (a complete course of chemotherapy includes 8 courses, and it takes 6 months)

The Inclusion Criteria for Oncologists Were as Follows:

• Being employed at a medical center affiliated to Kerman University of Medical Sciences

• Having at least 5 years of experience in the field of gastrointestinal cancers

In order to collect data, the researcher personally referred to the Javad'ol'aemme clinic for a month (from January 12 to February 12, 2019), distributed and collected the questionnaires among the physicians and patients. A 5-point Likert scale was used for scoring each question (1 = very low to 5 = very high). In order to analyze the data, descriptive statistics (mean, standard deviation, and percent) were used.

According to the sample of studies related to the application design (34) and meetings held between the research team, an mean of 3.75 (75%) was considered as the criterion for selecting the data elements required for application design. Practically, each of the data elements which had received a score of 3.75 and more by the participating patients and oncologists were included in designing and developing the application. Also, if the patients and physicians had different opinions on a certain element (i.e., the mean score of one or both groups was < 3.75), whichever group had a mean score of 3.75 would determine its inclusion.

Second Stage: Designing and Evaluating the Application

In this stage, based on the educational-informative needs and features identified in the previous step, we designed a mobile-based self-care application for patients with gastrointestinal cancer. The Java programming language was used to design the application in the Android software platform. Then, problems related to the usability and patients' satisfaction of the application were identified.

In order to evaluate the application, an invitation was sent to 40 patients referred to the chemotherapy department of Javad'ol'aemme clinic. A total of 35 patients agreed to participate in the study. Finally, according to the following inclusion criteria, 27 patients were selected to participate in the evaluation process.

Inclusion Criteria:

• History of at least 1 course of chemotherapy

• Ability to work with smart phone technology

To evaluate the application, first, the purpose and benefits of the study were explained to patients. Then, the program was installed on the mobile phones of patients. Also, explanations on how to use the application was provided to patients in the format of a video file. Then, the patients were asked to use the application for a week. They were asked to contact one of the study researchers if they had any questions or concerns.

To identify possible usability issues and users' satisfaction evaluation, the Questionnaire for User Interaction Satisfaction (QUIS) (Version 5.5) was used (35). The validity and reliability of this questionnaire have been measured in a previous study($\alpha = 0.94$) (36). The QUIS questionnaire consists of 6 sections: the participants' demographic information(3 questions), the user's overall reaction to the application(6 questions), screen (4 questions), the used terminology and information in the application(6 questions), the learning capabilities of the application (6 questions), and the general capabilities of the application (5 questions).This questionnaire is designed based on a 10-scale questionnaire in which each question can be answered by selecting one of the 0 to 9 options (0 to 3 = weak, 3.1 to 6 = average, and 6.1 to 9 = good) (35).

After 1 week of using the application by patients, the QUIS questionnaire was distributed among patients and then collected. Data analysis performed in both stages of the study was done by use of descriptive statistics (mean, standard deviation, and percent) in SPSS 22.

Ethical Considerations

The code of ethics IR.KMU.REC.1398.113 was obtained from the ethics committee of Kerman University of Medical Sciences to conduct the present study. Participation of both patients and physicians in the study was voluntary and they were free to leave the study at any time upon desire without consequences. Participants had given their informed consent before entering the study and the use of the application was free of charge for all patients during the evaluation process.

Results

First Stage: Identifying Educational-Informative Needs and the Required Features for Designing the Application

More than half of the participating patients in the needs assessment stage were men (51.9%). The majority of patients were older than 50 years (44.4%). The number of participating patients was as follows: 11 patients with intestine cancer (40.7%), 10 with abdominal cancer (37.0 %), and 6 with esophagus cancer (22.2%), respectively. Among the 4 oncologists who had participated in the study, 3 were men aged 45 to 50 years. The work experience of the 2 oncologists was <20 years.

The results gathered from the participants in the needs assessment stage were placed in the following 8 categories: demographic data, history, clinical data, managing psychological and psychiatric challenges, lifestyle information, management of side effects, communication possibility, and other application features (Table 1). In these 8 categories, 34 data elements were investigated to design and develop the application. Based on the patients' and physicians' opinion, all categories except the demographic information received a mean score of 3.7% and above. As for the demographic data category, the patients gave the following elements an average score of 3.75% and above: "Age," "Height," "Education," and "Nationality"; this was while the oncologists gave "Nationality" a mean of <3.75%; therefore, these elements were not included in

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Table 1. The Educational-Informative Content of the Designed Application for Gastrointestinal Patients Undergoing Chemotherapy

Categories	Data Elements	Patient	Physician
		Mean≠SD	Mean≠ SD
Demographic data	Gender	3.78±1.01	4.25±0.50
	Age	3.04±0.70	4.25±0.50
	Height	3.78±1.08	4.25±0.50
	Weight	4.04±0.58	4.75±0.50
	Education	3.81±0.87	4.50±0.57
	Nationality	2.74±0.85	2.75±0.95
History	History of drug consumption	3.76±1.08	4.50±0.57
	Commodities	3.26±0.72	4.50±0.57
	History of cancer	2.93±0.73	4.00±0.81
Clinical data	Access to pathological images	4.00±0.67	4.25±0.50
	Access to clinical test results	3.96±0.58	4.25±0.50
	Access to other clinical documents	3.85±0.66	3.75±0.50
	Dates of chemotherapy courses	3.85±0.90	4.75±0.50
	Number of chemotherapy courses	3.78±0.97	4.75±0.50
	Medications consumption method during chemotherapy	3.85±0.90	5.00±0.00
Managing psychological and psychiatric challenges	Being positive about the treatment and increasing patient's motivation	4.19±0.68	4.50±0.57
	Planning to better manage stress	4.19±0.68	4.50±0.57
	Providing motivational and supportive movies	4.15±0.77	4.75±0.50
	Coping method for dealing with emotional and mental-spiritual issues	4.30±0.82	4.25±0.95
Life style information	Observing healthcare tips	4.04±0.58	4.50±1.00
	Nutritional recommendations and its effect on strengthening the immune system	4.14±0.57	4.75±0.50
	Being informed about the disease and chemotherapy treatment	4.07±0.73	4.75±0.50
	Videos on physical activities and exercises that help	4.15±0.77	4.50±0.57
	Information on quitting smoking and other drug or alcoholic consumptions	3.78±0.97	4.00±1.15
	Spiritual health	4.15±0.81	4.50±0.57
Management of side effects	Preventing chemotherapy side effects	4.52±0.64	4.75±0. 50
	Sedating and treating chemotherapy side effects	4.59±0.57	5.00±0.00
	Frequently asked questions about side effects	4.56±0.64	4.75±0.50
Communication possibility	Effective relation with the healthcare providers or the patient's physician	4.30±0.72	4.75±0.50
	Developing an effective relation with others	4.19±0.78	4.50±0.57
Other application features	User's ID and password	3.78±1.08	4.25±0.95
	Reminders (timing of medication, chemotherapy session date, timing of exercise, next doctor's appointment, and etc.)	3.93±0.78	4.25±0.95
	Playing music when using the application	3.78±1.18	4.75±0.50
	Resources	4.30±0.73	4.50±0.57

designing the application. Of the 34 data elements, only 4 were excluded from the demographic data category. Finally, 30 data elements were considered for the application design.

Second Stage: Designing and Evaluating the Application

In this stage, an application was designed in Android Studio environment by means of the Java programming language for patients with gastrointestinal cancer who were undergoing chemotherapy, and later the application was evaluated. We named this application "Tumorfight".

The application is called the Tumorfight and begins with a welcome page. Users (patients with gastrointestinal cancer undergoing chemotherapy) enter the main page of the program by typing in their user's ID and password. In the main page (Fig. 1) and at the "Side effects prevention" section, information on preventing chemotherapy side effects, sedating and preventing chemotherapy side effects, environmental-health related tips, nutrition tips, and tips for the patient's caregivers are included. As the immune system suffers from various side effects during chemotherapy, this will help to reduce their severity.

In the "Sedating and Treating Chemotherapy Side effects" section (Fig. 2), first the user's demographic and clinical information are recorded along with some information about the user's history (Fig. 3). Then, information about lifestyle, management of chemotherapy side effects (16 side effects related to chemotherapy have been included here), and also management of psychological and psychiatric challenges is provided to help the user to best perform self-management processes during chemotherapy.

In the "Frequently Asked Questions" section, some answers have been provided to general questions about chemotherapy, diet, and side effects. In this section, necessary information is provided in the form of videos and text messages. Also, a separate section has been considered for users to communicate with other patients with gastrointestinal cancer undergoing chemotherapy and oncologists, if desired.

In the abovementioned section, communication is made possible through social networks (ie, WhatsApp). Other features of the Tumorfight application include allowing music to be played while using the program (which can be managed by the user), arranging reminders (timing of medication, chemotherapy date, timing of exercise, next

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Fig. 1. The main page of the Tumorfight self-care application

Fig. 2. Sedating and reducing chemotherapy side effects

doctor's appointment, etc.), and the ability to search through the pages for quick access to certain information.

Fig. 3. Recording user's information

Also, in the "Resources" section, the resources used for designing the content of the application are provided to prove to the patient that the content is from reliable resources.

Table 2 shows the demographic information of the participants in the evaluation process of the Tumorfight application. Based on Table 2, more than half of the patients were men (51.9%), and the majority of the patients were older than 50 years (44.4%). Respectively, the highest frequency was that of patients with intestine cancer (13 individuals), esophagus cancer (9 individuals), and abdomen cancer (5 individuals). Also, most patients (44.4%) had been undergoing chemotherapy for 6 to 12 months.

Based on Table 3, with respect to the user's satisfaction with the Tumorfight application, a score of 6.1 and above was obtained regarding all features of the application; therefore, the patients' evaluation of the application was that the program is good.

Discussion

In this study a mobile-based self-care application for patients with gastrointestinal cancer to manage chemotherapy side effects was designed and evaluated. According to patients and oncologists, most of the identified data elements and features were required to design the application. Based on the results of the needs assessment, the Tumorfight application had the following features: demographic data, history, clinical data, managing psychological and psychiatric challenges, lifestyle information, management of side effects, communication possibility, and

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Table 2. Demographic Information of the Individuals who participated in the Evaluation Process of the Tumorfight Application

Variable		Frequency	Percent
Gender	Men	14	51.9
	Women	13	48.1
Age	31-40	7	25.9
	41-50	8	29.6
	More than 50	12	44.4
Marital status	Married	19	92.6
	Single	8	7.4
Type of treatment	Esophagus	9	33.3
	Abdomen	5	18.5
	Intestine	13	48.1
Education level	Post-secondary	4	14.8
	Other	23	85.2
Chemotherapy duration	Less than 6 months	4	14.8
	6-12 months	12	44.4
	12-24 months	11	40.7

Table 3. Tumorfight Application Evaluation Results

Satisfaction Dimension	Mean±SD
User's overall reaction to the application	7.14±0.74
Screen	7.59±1.10
Used terminology and information	7.50±1.11
Learning features	6.73±1.90
General capabilities	6.65±1.02
Total	7.12±1.17

other application features. Among the 34 investigated elements in the 8 categories, only the 4 elements of demographic information (age, height, education, and nationality) were not considered in designing the application. Finally, according to the patients and physicians, 30 data elements were selected to design the application.

Fang Wang et al (37) designed and evaluated an application to help reduce patients' care needs and improve their quality of life after oral cancer surgery. Their application contained the following 4 news categories that contained the latest postsurgery treatments and healthcare recommendations: medical information (providing information about oral cancer, its treatment, its pain, and introducing cancer treatment centers to the users); and self-reporting (recording postsurgery signs and symptoms) and reminders for next appointments. Similarly, the Tumorfight application provides healthcare tips, the possibility of communicating with other patients, rehabilitation trainings, informative material about cancer and chemotherapy, and can remind the users about the next appointment session.

Jimin et al (23) also designed an application that was used by Chinese women who had breast cancer and were undergoing chemotherapy. The application offered self-efficacy, social support, symptom management, psychological issues management, and finally quality of life improvement for its users. The features of this application included user's registration, side effects management, the possibility to communicate in chat rooms, possibility to ask questions from experts, and to have personal chats with other patients. Similarly, in the Tumorfight application, users are registered, information on how to manage chemotherapy side effects are provided, and users are also allowed to communicate with physicians and other cancer patients.

One of the benefits of the above-mentioned study was the sharing of experiences among cancer patients who were undergoing chemotherapy in a personal chatting environment. This feature was not included in the present study. Fishbin et al (25) designed an application to help patients adhere to chemotherapeutical treatments and perform symptoms management. The application had 5 features for medication intake reminders, self-report of symptoms, recordings of medication intake results, educational booklet, social media networks, and personalized symptoms management feedbacks. In comparison, Tumorfight records users' demographic and clinical information and provides information on managing psychological and psychiatric challenges that may occur in cancer patients.

In addition to designing mobile-based applications, some studies have used smart wearables to improve patients' performance and health status. In a study conducted by Chiong et al (19), a mobile-based application and a wearable device were designed to improve physical functioning in patients with intestinal cancer undergoing chemotherapy. The application included rehabilitation training videos, information about the disease and its treatment, a grip strength test, a 30-second standing test on a chair, and a 2-minute walk test. The results of this study showed that for 12 consecutive weeks after using the application, patients could better manage their symptoms and reduce some others like nausea, vomiting, and diarrhea caused by chemotherapy. Similarly, the Tumorfight provides informative videos on exercising and physical activities, and it also contains videos on cancer and chemotherapy treatments to increase the patient's awareness.

In the present study, after identifying the educational needs and required capabilities, the self-care application was designed and evaluated. The findings that were obtained from the evaluation done by 27 patients showed that the usability and patient satisfaction of the application was good.

Eliasson et al (38) evaluated a mobile-based application to identify the severity of nausea in children undergoing chemotherapy by recording their facial expressions. After 60 courses of chemotherapy and using this application, these children and their parents shared that the application was user-friendly, visual, and time-saving, especially when recording user's information.

A number of studies have evaluated an application designed to investigate the role of self-management processes in reducing the side effects of chemotherapy, based on the opinions of both intervention and control groups. Kim et al (20) also designed an application to improve self-management and reduce the side effects of chemotherapeutic medications in cancer patients. In line with the results of this study, the intervention group was highly satisfied with the application. The present study showed that the use of mobile games is an easy, fun, and effective method that helps educate patients and improve their treatment outcome.

Ngo et al (39) also evaluated the opinions of cancer patients undergoing chemotherapy about a chemotherapy care coordination application and its usefulness. The participants were divided into 2 groups of intervention and control. The intervention group mentioned the applicabil-

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ity of the application, its compatibility with other applications (such as the patient's electronic portal and electronic records), easiness to use, fast functioning, and portability. Regarding its benefits, they also expressed that as the application allowed them to communicate with healthcare providers, during their chemotherapy courses, and receive answers to the questions they had, it is quite useful.

Based on the above-mentioned studies, it is deduced that in evaluating applications the following factors can be considered: evaluating the user's opinion regarding the usability, advantages, efficiency, and effectiveness of self-care and self-management applications. The findings of this section have shown that by evaluating applications, it is possible to effectively identify any possible issues and gaps that an application may have. Then, application developers can address these issues and upgrade or modify the application so that it can become more desirable to users and to be used more regularly.

Study Limitations

The fact that the opinions of only patients with gastrointestinal cancer who were referring to Javad'ol'aemme specialized clinic in Kerman were taken into consideration, in both stages of designing and evaluating the application, is one of the limitations of this study. It is recommended that a study be conducted in other healthcare centers as well. Also, the physical and psychological conditions of some patients undergoing chemotherapy made it difficult for them to participate; therefore, only a limited number of patients entered the study. For future studies, more patients can be included, and the research can be conducted over a longer time period.

Conclusion

In this study, a mobile-based application addressed to patients with gastrointestinal cancer undergoing chemotherapy was designed and later evaluated to help these patients manage the side effects caused by chemotherapy. This application can record the users' history, lifestyle matters, as well as their demographic and clinical information. Additionally, it provides patients with useful information on ways to manage their psychological and psychiatric challenges and chemotherapy side effects. The application also allows its users to communicate with oncologists and other cancer patients.

Based on the results of this study, it can be concluded that this mobile-based application can be an effective tool in reducing the side effects of chemotherapy in patients and improving their general health status, as it is easily accessible and cost-efficient. Another advantage of the application is that it offers effective communication between patients and patients or between patients and physicians. Although the application can never replace physicians, it is an effective tool that improves self-care and self-management processes, especially for patients who undergo chemotherapy and after treatment they cannot easily access their specialists. The application is also time- and cost-efficient for both patients and oncologists, as it will reduce the number of unnecessary in-person visits to doctors.

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Conflict of Interests

The authors declare that they have no competing interests.

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