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Abstract

Background The prevalence and chronic nature of Inflammatory Bowel Diseases (IBD) is a significant global concern. As the essential part of treatments approach, patient adherence to treatment protocols and self-management practices are crucial to = IBD management. Healthcare initiatives focused on chronic conditions are strongly needed to consider various aspects of gamification and how it can positively affect self-management.

Aim The current cognitive study aims to develop a mobile application to integrate the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) instructional design model and elaborate on a gamification design based on the reputable Sukr Wheel framework.

Methods The current study uses the ADDIE approach to integrate behavior change strategies derived from the selfmanagement theory using the Sukr Wheel gamification (My IBD Buddy) framework on the Android platform.

Results The final evaluation was conducted over 14 days. User satisfaction comprised 22 participants aged 20 to 64, all diagnosed with inflammatory bowel diseases. System usability was measured on a scale ranging from 50 to 100. The average usability score for the entire user group was 80.68, indicating a "good" level of satisfaction among the program users based on the ranking scale.

Conclusion "My IBD Buddy" mobile application, equipped with gamification for IBD patients, enhances self-efficacy and self-management.

Keywords Mobile application, Inflammatory bowel disease, Self-management, Gamification, ADDIE Model

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Introduction

Inflammatory Bowel Diseases (IBD) are globally known as prevalent and chronic gastrointestinal conditions [1]. As an essential part of a therapeutic approach, enhancing patient adherence to treatment protocols and selfmanagement practices for IBD are of an paramount importance [2]. Given the advancements in technology and users' reliance on mobile phones and mobile applications, the technology can effectively manage chronic diseases [3]. While the existing applications can facilitate disease management, they often lack certain motivational aspects [4]. Fortunately, several methods and processes hold promise for effective changes to user behavior and contribution to healthcare systems through gamification [5]. Gamification entails integrating gaming elements and mechanics into non-gaming contexts [6]. The tool has found widespread use in various domains, including healthcare, to facilitate interaction, behavior modification, and enhancing motivation [7].

Self-management, which enables people to continue functioning satisfactorily on a daily basis in spite of chronic illnesses [8], is crucial for improving the quality of life, lowering health care utilization, and lessening the burden of these conditions [9–12]. Making decisions, acting, and using resources maximally to actively participate in medical management, embrace new behaviors, and manage emotions are all examples of self-management [13]. Novel self-management interventions that appeal to the interests of young people who grew up in a digital age are currently needed [11, 12, 14].

Although there has been much praise for the effectiveness of mobile health apps as a low-threshold treatment delivery mechanism [15], there is little evidence to support the effectiveness of commercially available applications [16]. Gamification has been recognized as a promising approach to boost intervention engagement, which can lower attrition and enhance the desired treatment outcomes [17, 18]. Gamification is the process of changing processes, systems, services, goods, or organizational structures to provide game-like experiences [18]. The use of game elements in activities not typically associated with games is known as gamification. Despite being a subset and component of gamification in general, rewards and incentives are only used within the intervention and have no real-world or tangible economic value [19]. As a current trend in gamification research, customizing the game elements to the user's profile can enhance their experience when interacting with a gamified system [20, 21].

Five gamification principles that are theory-driven and unifying were presented by the model of gamification principles for internet interventions. Regarding the use of gamification, these principles are stand-alone, implementable items [22]. Five distinct but connected constructs make up the model: feedback, visibility, supporting player archetypes, meaningful purpose, and meaningful choice. The Wheel of Sukr framework is used to gamify chronic illness self-management that blends game techniques, behavior modification strategies, and chronic illness self-management methods. Fun, esteem, growth, motivation, sustainability, socializing, self-representation, and self-management are the eight themes that make up the Wheel of Sukr, and there are several components in every theme as well [23].Furthermore, the Analyze, Design, Develop, Implement, and Evaluate (ADDIE) model is known as a systematic instructional design (SID) model. It is a widely used model to develop electronic learning applications, and is made up of stages of analysis, design/development, implementation, and evaluation [24, 25]. Also, as scientifically proven, implementing the ADDIE approach is effective to develop instructional systems in organizing health interventions, health domains, and effective patient follow-up. Moreover, it is an efficient information transfer method in adult education which is extensively used to develop multimedia instructional content [26].

Given the significant annual toll that gastrointestinal diseases take, both directly [27-29] and indirectly [30-33], healthcare systems face numerous challenges in providing these patients with equitable and costeffective therapeutic solutions [34]. In patients with IBD, specific metrics are particularly important, such as compliance and adherence [35]. The problem becomes more complex in patients with IBD, whose medical diet involves a combination of medical and psychological approaches and necessitate high-demand manipulations [34, 36, 37]. Mobile apps with gamification features would, therefore, be a promising remedy.

Notably, there is a sharp contrast between the large number of mobile health applications available for treating GI tract disorders and the dearth of reliable related research [38, 39]. Alongside potential risks like inadequate data protection policies, privacy violations, treatment prescriptions without informed consent, inappropriate information, inaccessibility in emergency situations, and data abuse, there is still a wide gap [40, 41].

Aim

The present study aims to describe the systematic developmental process of a mobile application that integrates the ADDIE instructional design and development model and applies the Sukr Wheel framework to design a gamification self-management system for patients with IBD.

Methods

The ADDIE model is part of the systematic instructional design (SID) family, and consists of five steps: Analysis (A), Design (D), Development (D), Implementation (I), and Evaluation (E). It is widely used for developing e-learning applications, enabling educators and instructional designers to create structured and effective learning experiences, and also allowing for continuous revisions during the educational material design process [42, 43], Evidence shows that the ADDIE approach is effective for developing educational systems in healthcare organization and patient follow-up [44-46]. Moreover, it serves as an effective method for information transfer in adult education and is extensively used for producing multimedia educational content [47]. Figure 1 shows the stages of the ADDIE framework as modified based on the present study.

The Sukr Wheel framework is a structure for gamifying the self-management systems of chronic diseases, which combines behavior change methods, gamification techniques, and chronic disease self-management strategies and comprises the following eight components: Fun, Esteem, Growth, Motivation, Sustainability, Socialization, Self-Representation, And Self-Management [48, 49]. The Sukr framework highlights the connection between gamification and behavior change methods.

Analysis

The first step in the ADDIE model is analysis which employs a comprehensive perspective towards system design. This step mainly aims to identify the features and general requirements of the system. It includes the designation of the current trends of self-management in IBD, extraction of properties, characteristics, and major features of proposed system along with elucidation of the educational content structure in case of IBD disorder. In this stage, for the purpose of analysis, evidence-based scientific literature review methods were used along with interviews with experts. To achieve this goal, the following steps were defined:

Extracting informational and supportive needs in patients with IBD

This step used a multi-phase approach, including a comprehensive review, expert opinions via the Delphi technique, and patient surveys to identify and prioritize the informational and supportive needs of IBD patients.

Reviewing existing technologies and applications on IBD self-management

A survey was conducted to evaluate the existing mobile applications for the self-care management of IBD. Relevant keywords were used to identify and extract the features of these applications, which helped make the right decisions on idea innovation and support features in each mobile application.

Identifying general requirements of a self-management system used by IBD patients

Based on the available scientific studies and the expert panel's opinions, the main features of the system were extracted.



Fig. 1 Phases of the application development based on the ADDIE model

Design

During this phase, researchers focused on developing educational content and the conceptual design of a mobile application to support patients with IBD. They addressed the key questions about educational content presentation, the media used, and implementation of gamification techniques. Expert meetings were held with gastroenterologists, psychologists, nursing faculty, and specialists in human-computer interaction and medical informatics. The discussions aimed to incorporate self-management concepts into gamified scenarios, select appropriate educational media, and establish effective educational strategies. The planning involved defining the features, functionalities, and protocols necessary for IBD manaement. It included the following steps:

Designing educational content

The application content was meticulously developed and evaluated to impart knowledge on comprehensive skills to manage IBD. It encompassed topics such as an overview of IBD definition, diagnostic tools, pharmacological and non-pharmacological management, sexual relationships, fertility, and issues related to IBD in women, risk of colorectal cancer in patients with IBD, cosmetic surgeries in these patients, use of other medications, other viral and infectious diseases concurrently occurred in patients with IBD, complementary medicine, nutrition and nutritional supplements, preventive care, and lifestyle behaviors. The designed educational content was evaluated by experts and target population in several steps to ensure content validity and appropriate presentation. The panel of experts included five faculty member gastroenterol pathologist, a nutritionist, a clinical psychologist, a gynecologist, and two internal nursing specialists using Suitability Assessment of Materials (SAM) and Patient Education Materials Assessment Tool (PEMAT) [50].

Paper-based initial design (sketch) of system modules and system features

A paper-drawn wireframe was iteratively designed to enhance comprehensibility and define the application modules. This wireframe aimed to encapsulate the entire subsystem.

Designing gamification mechanics based on the Sukr framework

Based on the designed subsystems, the game elements rooted in the Sukr framework, have been crafted to align with the goals and objectives of the system and its audience.

1) Fun

Based on the fun component within the Sukr framework, challenges, competitions, point scoring, rewards, and badges for completing activities or advancing in the selfmanagement system for IBD were extracted. However, in meetings with clinical experts and medical informatics professionals, the research team concluded that competition should not be linked with self-management tasks or patients' medical test results. Rather, they should relate to the frequency of user interaction with the system. Therefore, the concepts for this component were designed based on this principle.

2) Self-management

To implement the self-management component in the Sukr framework for the IBD self- management system, a logbook was used, including symptom reporting, data visualization, alerts based on input symptoms, symptom monitoring, and feedback based on the input information.

3) Growth

Providing rewards and incentives, leveling up on the leaderboard, earning points, displaying progress, and defining habits and small goals are aspects that sre considered in this section to change behavior, empower the user, and achieve small goals and habits. These elements formed the basis of designing the growth component.

4) Motivation

The focus of design in this step was to create motivation for task completion using motivational techniques, including changing the user's position on the leaderboard, earning points for completing tasks, and providing rewards or congratulations on task completion.

5) Socialization

Considering that peer support is essential in chronic illnesses, this aspect was also addressed within the Sukr framework. Therefore, this design focused on establishing interaction with peers through social networks and sharing status updates.

6) Esteem

To foster a sense of esteem and admiration for patients with IBD, elements such as the leaderboard, progress bar, level ups, and badge awards were designed. It encourages patients to manage their conditions effectively and positions them as role models for peers.

7) Self-representation

To ensure the element of independence, which is a critical need in self-management for chronic diseases, a customizable user profile was designed, incorporating gender-appropriate avatars and patients' ability of setting their own goals and habits. Control over choices and activities can lead to patient empowerment.

8) Sustainability

Elements that stimulate the narrative theme, facilitate interaction, and remind users to engage in the app through user interaction were designed to achieve the goal of sustainability component.

Application naming, designing graphic/narrative elements and user interface

This step involved assigning a name to application, designing an application logo, and formulating scenarios for multimedia educational content. Separate story scenarios were developed for each content to facilitate animation creation.

Evaluating the user interface (UI) wireframe

High-fidelity screen layouts, rooted in Figma wireframes, were implemented, and rigorously tested for pixel sizes, proportions, and density on mobile phones.

Development

The results of analysis and design phases provided the knowledge necessary for the development stage. This stage was divided into two parts, development of prototype and testing and evaluation of prototype.

Development of a prototype to manage IBD: multimedia content and educational animations

The initial version of the gamified mobile application and the educational content, based on animations for user understanding, was developed for the Android operating system using Android Studio 2022.

Evaluation of the prototype for IBD management Evaluation by a software specialist (alpha test)

In this step, alpha testing of the initial draft of prototype was done by the application development team. In fact, at this stage, the bugs that were not discovered in the previous stages were discovered and fixed. Moreover, this test allows the quality and performance of the application to be evaluated before release.

User interface prototype evaluation using the exploratory method

Upon approval of the prototype version, the user interface of prototype was evaluated using the heuristic usability method using Nielsen's 10 heuristics [51] by usability experts with a background in medical informatics, health information management, or health information technology with experience in designing, developing and assessing mobile health applications and proficient in conducting exploratory evaluations. Studies show that three to five specialists can identify 74 to 87% of usability issues [51-54]. Therefore, this number of evaluators was suitable for a heuristic evaluation of our system's user interface. The evaluators independently assessed the prototype using a standard form based on Nielsen's 10 heuristic method [55], rating any discrepancies based on severity on a five-point severity scale ("No Problem," "Minor Problem," "Moderate Problem," "Major Problem," and "Critical Problem"), which corresponded to severity levels ranging from zero to four, respectively [56-59]. This step was done in four phases:

Phase 1: Preparation and independent evaluation

Each evaluator independently assessed different sections of user interface using Nielsen's checklist (Suppl. Table 1) and documented their findings in a problem identification checklist. The validity and reliability of checklist had been previously confirmed in another study [60]. The problem identification form was used to precisely describe the identified issues and included a four-column table with the problem name, problem description, problem location, and violated usability principle. According to this method, evaluators were asked not to share their opinions with each other before completing the evaluation, as one evaluator might not detect a large number of issues, whereas various evaluators could identify a wide range of unique problems. Therefore, a more comprehensive result could be obtained after combining the evaluators' findings.

Phase 2: Consolidation identified issues

The issues identified by the independent evaluators were combined, and after removing duplicates, they were compiled into a single list. This consolidated list was then distributed among the evaluators for final discussion and validation. Evaluators held online meetings via Skype to discuss the identified issues and ultimately reached a consensus on the final list of problems.

Phase 3: Severity rating of issues

During this phase, evaluators re-examined the system's user interface and independently rated the severity of

issues based on three criteria (Fig. 2), and they rated the severity of problem on a 5-point scale (Table 1).

Phase 4: Categorization

The average severity of each identified issue was measured, and each usability problem was categorized based on its average severity into one of the five categories [61, 62]. The severity scale of problems based on average severity is as follows:

- 0. No Problem: Average severity 0-0.5
- 1. **Cosmetic**: Average severity 0.6–1.5
- 2. **Minor**: Average severity 1.6-2.5
- 3. Major: Average severity 2.6-3.5
- 4. Catastrophic: Average severity 3.6-4

Prototype evaluation by panel of experts

The revised version of the prototype was provided to a panel of experts (medical informatics specialists, gastroenterologists, and psychology faculty member). They were asked to use the application processes for one week and record their suggestions for potential improvements in consultation with the development team. Additionally, the clinical experts were asked the following questions:

- 1. Do you find the application easy to use?
- 2. Is there any aspect that you think needs to be improved?
- 3. What model of mobile phone did you use the application on?
- 4. Did the application fit well on your mobile screen?
- 5. Do you think the application adequately covers all self-management content?

Furthermore, the time spent using the application and any errors encountered were also recorded.

Moreover, the comprehensibility and applicability of all educational modules were independently assessed by five evaluators using Patient Education Materials Assessment Tool for Audiovisual materials (PEMAT-AV) checklist tool (Suppl Table 2). It consists of 13 items measuring understandability and 4 measuring actionability [63].

The research team thoroughly analyzed and evaluated stepwise suggestions, which resulted in the development of the second and third drafts. These were iteratively presented to experts until it was affirmed that no further changes were needed and no program-related errors were found.



Fig. 2 Criterias for severity rating of issues

Table 1 Classification of p	oroblem severity
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Severity Ratin	Name	Description
0	No Problem	No Problem
1	Cosmetic	It does not need to be modified unless there is extra time in the project
2	Minor	The problem should be fixed, but it is in the lowest priority
3	Major	Fixing this problem is important, so it should be a high priority
4	Catastrophic	The problem must be solved before the final release and development of the product

Implementation

The identified problems were thoroughly examined and rectified by the technical team leading to the development of a new draft. Based on the feedbacks provided by experts, the final version was implemented, and delivered to the experts to ensure the resolution of potential errors and shortcomings.

Evaluation of the implemented version by field experts and target users (Beta test)

A beta version of the MY IBD Buddy was implemented after comprehensive consultation with a panel of field experts including gastroenterology subspecialists, members of psychology and nursing faculties, and medical informatics academic members. Then, ten patients with IBD used the application for one week and reported possible shortcomings. The reported issues were addressed in consultation with the team of developers. When patients and clinical experts suggested no further changes, the finalized program was presented.

Evaluation of the final version user interface using the exploratory method

The final version was also assessed for user interface wireframe by usability development experts through an exploratory method. They evaluated and ranked the cases that did not comply with the afore-mentioned principles in terms of severity and deterioration on a 5-point scale [57, 64, 65]. Data collection was done through a standard form (Suppl Table 2) based on the method proposed by Jakob Nielsen's 10 usability heuristics evaluation [55].

Evaluation of user satisfaction

Having completed the implementation phase, the application was assessed by target users via a System Usability Scale questionnaire (SUS) (Suppl Table 3). It consists of 10 items rated on a 5-point Likert scale ranging from strongly disagree (1 point) to strongly agree (5 points). This scale is considered a valid, reliable, and sensitive tool to measure user satisfaction with the system [66]. The final score would range between 0 and 100, a higher score showing a better usability potential of system. A score ≤ 50 is considered as not acceptable, >68 as moderately acceptable, and ≥ 85 as highly acceptable [67–69]. The questionnaire was submited to patients, who visited specialty clinics, after considering certain inclusion and exclusion criteria. The inclusion and exclusion criteria are shown in Table 2. The sample size calculation was based on the number of participants according to the problem identification percentage curve [70–72]. According to this study, at a confidence level of 90%, approximately 22 subjects were required, and at a confidence level of 80%, approximately 15 subjects were needed. Therefore, the sample size for this study was estimated at 22 at a 90% confidence level.

The participants used the application for 14 days for at least 15 min a day. The patients were in close relationship with the technical team for any required issue or help. Following this time, they filled out the questionnaire in a web-based platform.

Results

Analysis

Extracting informational and supportive needs in patients with IBD

First, the guidelines of the American Gastroenterological Association, the American College of Gastroenterology, the American Crohn's and Colitis Foundation, the European Crohn's and Colitis Organization, and the consensus guidelines of the British Gastroenterology Association were reviewed. Similarly, a comprehensive literature review was made of the important components and indicators used in the thematic separation of educational content. The information and support needs of patients with IBD were extracted from a literature review of four databases (PubMed/Medline, CINAHL, APA PsycInfo, Psychology and Behavioral Sciences Collection, APA PsycArticles, and ProQuest). The search was done using the related words in a period of 22 years. Two key journals in IBD were manually searched [73, 74]. A total number of 75 studies on the evaluation of information and support needs of patients with IBD were examined, and in this study, 55 information needs and 34 support

Table 2 Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
(1) Diagnosis of inflammatory bowel diseases	(1) Patients with serious mental illnesses.
(2) At least 18 years of age	(2) Inability to communicate with the research team and adhere to study requirements.
(3) Ability to speak and read Persian	(3) Unwillingness to continue participation.
(4) Ability to use smart devices such as mobile phones and the internet	
(5) Informed consent and voluntary participation in research	

needs were extracted. The most important information needs of patients in this study were "nutrition/diet information", "drugs and side effects information" and "treatment/treatment and side effects information" and "patient education" was one of the most important support needs of IBD patients [73, 74].

Then, in order to determine the important information and support components from experts' point of view towards IBD, the Delphi technique was used [75]. Having conducted three rounds of Delphi, "Drug and treatment information and side effects" and "Skills to deal with and adapt to the disease" were, respectively, among the most important information and support needs identified from the experts' point of view. Finally, in order to determine the priorities of information needs and support for patients with IBD, exploratory factor analysis and confirmatory factor analysis were performed [76] using the opinion of 521 patients, based on which 25 information needs and 15 support needs were identified. The most important information need from the patients' point of view was found to be "nutrition/diet information" and the most important support need was "providing multidisciplinary services".

Reviewing existing technologies and applications on IBD self-management

Mobile applications for IBD self-care available on Android and iOS platforms were reviewed to determine innovation and features supported in each application. The keywords used were "IBD", "Crohn's", "ulcerative colitis" and "Colon". Seven mobile applications were selected and downloaded based on the latest versions or updates in Google Play and App Store, and their information was recorded. Most mobile phone applications that were reviewed focused on tracking intestinal symptoms or teaching general information about IBD. None of the native or non-native mobile applications focused on teaching all aspects of disease, mental health and disease surveillance with gamified techniques. Also, how educational materials were presented in the existing applications was based on recorded videos or long and boring texts. It was decided to provide educational content in a multimedia format, including a combination of short and beautified texts with related images, sounding on the texts, and creating related animations based on educational concepts.

Identifying general requirements of a self-management system used by IBD patients

Based on the available relevant scientific studies and the results of steps 1 to 2, a list of general features and modules considered for the system was prepared and in an online and face-to-face meeting with seven experts including two adult gastroenterologists, one clinical psychologist, two experts affiliated with the nursing faculty, and two medical informatics specialists were examined and surveyed. Finally, the main features of the system were extracted. Interview sessions were held in three universities of medical sciences in Iran. Some interviews were conducted on Skype due to the distance. The focus at this stage was on the content of application for teaching self-care skills to IBD patients and how to present it.

Design

Considering scientific evidence, the decision-making process in the design phase required the participation of at least 14 specialists [77]. A total number of 51 online and face-to-face meetings were held with two experts in gastrointestinal and liver diseases, a clinical psychology, two nursing faculty members, five human-computer interaction specialists (UX/UI designers and mobile app developers), three medical informatics experts, and a game design expert.

Designing educational content

The mobile app content was designed to provide patients with information on comprehensive IBD management skills [50]. The researchers developed a training file in 12 chapters for the mobile application to cover the relevant content. The educational content designed to ensure the suitability of text content for the mobile application was evaluated by experts and the target group. The results of evaluation showed that the self-care educational materials for inflammatory bowel disease patients are valid in content and appearance.

Paper-based initial design (sketch) of system modules and system features

At this stage, a low fidelity wireframe was designed to better understand the generalities and specify the application modules. In this wireframe, the generalities of all subsystems were specified. This step was repeatedly reviewed and modified by the panel of specialists and finally its final version was designed. Figure 3 shows the initial home page design.

Designing gamification mechanics based on the Sukr framework

Based on the designed subsystems, the elements of game were developed according to the Sukr framework to match the goals and objectives of system and its audience. Attempts were made to include all elements of cycle and their links to the system modules (Table 3).

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Fig. 3 Low-fidelity wireframe of the main page of the application

Application naming, designing graphic/narrative elements and user interface

Story scenarios for making animations were presented separately for each content. Also, the logo of application was first designed on paper by the main researcher of project and after the approval of other members of the research team, after three modifications, the final version of logo was designed in Photoshop. The application logo considers all aspects of the lifestyle of IBD patients (Fig. 4).

Evaluating the user interface (UI) wireframe

Based on the results of the previous steps, the user interface high-fidelity wireframe was designed using Figma. All designs underwent scrutiny and evaluation by five UI/ UX specialists, three medical informatics specialists, and a game design expert.

Development

Development of a prototype to manage IBD: multimedia content and educational animations

A prototype mobile application based on the operating system named "MY IBD Buddy" was developed using

Android Studio2022. The multimedia content, such as story-based animations, was designed to effectively convey the educational content particularly in a stress-free context without background noise supported by a calming background music. The leading researcher used video scribe software to develop these animations.

Evaluation of the prototype for IBD management *Evaluation by a software specialist (alpha test)*

In this stage, five software experts in the development team, including senior developers and testing experts, tested and evaluated the initial version of sample to ensure the system performance and find possible errors. The main identified bugs were quickly fixed and resolved.

User interface prototype evaluation using the exploratory method

The exploratory evaluation of user interface wireframe showed each feature received an average score of 3.6-08. These scores indicated the presence of minor to severe usability problems. The evaluation, carried out by five assessors, identified 105 issues in ease use. Having consolidated and summarized these issues, 50 unique problems were found. Among these, the most severe problem was associated with the principle of "free range of user action and control over the system," while the least severe pertained to the principle of "compatibility between the system and the real world" (Table 4). Furthermore, any identified applicability defect was rectified during this stage. The overall mean scores for comprehensibility ranged from 94.33 to 97.5, and for feasibility, the range was between 97.99 and 100. Hence, the second and third versions of application were developed accordingly.

Prototype evaluation by panel of experts

Having fixed the functional defects and identified bugs, the system was evaluated by the field experts and their suggestions were used. Table 5 shows the experts' main suggestions, including changes to the menu titles, adjustments to the organization of educational content, and modifications to the presentation of content within the mental health section. Also, all educational modules were evaluated separately by the same five evaluators using the PEMAT-AV tool in terms of comprehensibility and applicability. The mean overall scores for comprehensibility ranged between 94.33 and 97.5, and the overall mean scores for feasibility ranged between 97.99 and 100. Then, the proposals were evaluated and analyzed by the research team, and the next versions were developed and recurrently provided to the experts so that they found no errors left. The characteristics of usability expert participants are shown in Table 6.

Table 3 Mapping gamifica	tion elements to subsystems of application		
Elements of the Sukar cycle	Sukr cycle concepts	Relevant gamification elements in the self- management system of inflammatory bowel disease patients	Related subsystem
Fun:	 Challenges and competition. Earn points or prizes. Reward badges and to do exercises or make improvements. 	 Obtaining points, awards and badges based on the completion of the profile form, monitoring forms for disease symptoms and related symptoms, medication registration, reading the content of training, getting a passing score in the training tests. The challenge of nutrition monitoring. The challenge of medicine. The challenge of medicine. The challenge of form sing disease-specific knowledge. The challenge of completing the short test file. Daily walk challenge. 	A separate page to view user ratings symptom monitor and manage education
Self - management	A logbook of symptom reporting, data visualization and trend alerts to monitor patient symptoms, receive feedback based on input information.	 Storage of test results and intestinal symptoms, pain or other disease-related symptoms. Display the stored data in tabulated form. Tracking and monitoring of gastrointestinal symptoms and other disease-related symptoms. Provide feedback based on patient status and symptoms, categorize users. 	User registration Blood, stool and colonoscopy tests Symptom monitoring and management
Growth	 Provide real-time feedback through rewards and incentives, level up on the leaderboard, earn points. Achieving the predefined goals. Showing progress. Defining habits and setting small goals. 	 Feedback on the results of educational tests using a talking avatar and feedback. Feedback on disease management habits such as taking medication on time, recording with program of the disease. Follow the program of colonoscopy preparation methods. Provide feedback in terms of graphs of disease activity. Provide feedback on to take medications and possible interactions. Display a summary of the patient's condition in tabulated form. 	Blood, stool and colonoscopy tests Automatic colonoscopy preparation program Symptom monitoring and management Education Medication management my situation
Motivation	 Position in the leader board. Points for completing tasks. Leveling up. Encouragement. Rewards and congratulations on completion . 	 Unlocking educational files to access more educational files. Free doctor's visit (outside the time scope of study). Changing user level. 	Display the user's nitrogen table Symptom monitoring and management Education Medication management
Socialization	Interaction, using social networks, discussion forums with peers, support from peers, sharing status .	 Using social networks to communicate with peers. Sharing the situation and experiences under the supervision of expert staff. Supporting and interacting with the multidisciplinary team including a specialist in digestive diseases with a focus on inflammatory bowel diseases and a mental health specialist. 	Support

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Elements of the Sukar cycle	Sukr cycle concepts	Relevant gamification elements in the self- management system of inflammatory bowel disease patients	Related subsystem
Esteem	- Leaderboards - Level up - Progress bar - Receive a badge congratulate	 Scoreboard. Level change based on training. Change the level based on the completion of information monitoring of disease symptoms. Progress bar for studying educational files and playing educational games. Progress bar based on completion of symptom monitorior ing forms. 	View the user's rating table User registration Symptom monitoring and management Education
Self - representation	Defining user profiles, using custom avatars, setting goals and habits.	 Personalized user profile based on user name. Apply avatars that match the user's gender automatically. 	Home page and user registration
Sustainability	The use of stimulating elements such as the theme of the story, establishing interaction.	 Multimedia training with animation presentation. Monitoring the patient condition and interacting with the patient. 	Symptom monitoring and management Education Support



Fig. 4 Application logo

Implementation

Evaluation of the implemented version by field experts and target users (Beta Test)

The final version of the MY IBD Buddy program included eight modules comprised of 1- login and registration page, 2- patient profile (a clinical disease history, drug and dietary allergies, automatic BMI calculator, smart weight recommendation, and a summary of the patient status including medications, tests, and tracking disease-related symptoms as tabulated), 3- My symptom monitoring and management with five sub modules: interaction monitoring (assessing satisfaction with the application), psychological monitoring (monitoring anxiety and depression status, quality of life, and disease selfefficacy), medical and clinical monitoring (monitoring disease activity using disease activity assessment indices and providing feedback to patients based on input symptoms, monitoring fecal calprotectin levels, and treatment adherence), educational monitoring (assessing disease-related knowledge), and nutritional monitoring (food diary). There are also other features such as 4- My medications (managing medications, viewing drug information, and proper drug usage methods, medication reminders, checking drug interactions, authorized and unauthorized drugs for IBD patients, viewing authorized and unauthorized drugs during pregnancy and breastfeeding for patients with IBD), 5- My Tests (manual and visual entry of blood, feces, and colonoscopy tests, interpretation of blood and fecal test results, saving tests), 6- Colonoscopy Readiness Program (a list and electronic form of pre-colonoscopy tasks, setting reminders, comprehensive pre- and post-colonoscopy instructions), 7- My Education (self-management concepts taught in 12 separate chapters, where the user, after viewing each chapter, must answer educational questions related to that chapter, gamified and presented in a narrative scenario, education on mental health concepts, relaxation and mindfulness techniques). Moreover, 8- My Support (interaction and communication with gastroenterology and mental health specialists, interaction with peers through a discussion forum) is another feature of the application (See supplementary file1. Suppl Figs. 1,2).

Evaluation of the final version user interface using the exploratory method

During the exploratory evaluation of user interface wireframe, each feature received an average score of 1 to 2.4, indicating a minor to moderate usability problem (Table 7). These problems were resolved by the technical team. Figure 5 compares the identified errors in the alpha and beta versions.

The reported errors and problems reported by 10 patients were resolved as well. At the end, the final version was released.

Evaluation of user satisfaction

Twenty two participants were diagnosed with IBD. They were aged 20 to 64 years, and evaluated the user satisfaction of application. The system usability was evaluated on a scale ranging from 50 to 100. The average usability score for the entire user group was 80.68, indicating a "good" level of satisfaction among the application users based on a ranking scale (Figs. 6 and 7). Table 8 provides a more detailed description of the participants' demographic features.

Discussion

The current study aimed to develop the first-ever remote medical system using gamification techniques to empower all subgroups of patients with inflammatory bowel diseases (IBD). A wide range of applications and communication technologies are used in the remote healthcare management of IBD, such as remote monitoring, remote consultation, and remote education. One purpose of the application is remote monitoring, including diagnosis, monitoring, treatment, patient education, or remote follow-up.

In the present research, the ADDIE model was used [78, 79] to ensure that the learning process was wellorganized, structured, and successful by providing a methodical and adaptable approach to instructional design. Training developers and instructional designers had historically employed the ADDIE model as a generic process [25, 80, 81]. A methodical approach to

Table 4 Exploratory evaluation scoring of MY IBD Buddy user interface based on Nielsen's principles (alpha)

The principle of usability	Exp	ert op	inions			Problem statement	Average	The severity of the
	1	2	3	4	5		degree of intensity	problem
Visibility of system status	3 1 2 1 3 3 3 3	1 2 3 2 3 3	1 3 2 1 2 2 3	1 1 2 3 3 2 2	1 2 1 3 3 3	 In my profile, date of surgery, and last test date, selection does not work. In the information editing section, after editing information and pressing the button to register and save information, the system does not show any reaction. In the medical certificate section, under the colonoscopy preparation program icon, the suggested preparation program, view the program, after selecting the items, there is no key to confirm and the system does not give us any feedback. In the medical certificate section, under the icon of my tests, blood and stool tests, the registration option does not work. Is Multiple Calculation section does not work. In my profile, "Register and save information" is network. 	1.4 2 1.8 2.6 2.6 2.8	Cosmetic problem Cosmetic problem Minor problem Major problem Major problem Major problem
Match between system and the real world	1	0	1	1	1	The icon used for "my tutorial" is not suitable. This icon in the real world is a symbol of graduation.	0.8	Cosmetic problem
User control and freedom	3	4	4	4	3	While working with the application without exiting the application, I encountered an error (bug) exiting the application and had to select the option clear cash Log in again.	3.6	Catastrophic problem
Consistency and standards	1 2 2 1 3 1 3 1 2 2 1 1 1 1 1 1 1	1 1 2 1 1 1 2 2 3 1 1 1 1 1 1 1 1 1 1	2 1 2 2 2 2 3 3 2 4 1 1 1 1 1 1 1	1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	1 2 2 3 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	 In the section about us, information about the disease should not be included. The username at the top of the page must be the entered username. The icon used next to the username is not in accordance with the standards. The arrow that appears on the screen for scrolling is not in accordance with the standards and covers the text. In the 'Monitoring and managing my symptoms'' section "Monitoring Education "The title 'food diary'' is not appropriate. In the 'Drug information' section, after selecting this icon, we will enter a page titled "Identity certificate of the disease" at the top of the page. This is not correct and the titles should be the same. In the "My Education' section, there is no information about the person's education and we encountered the message "You have no message". In the section "Monitoring and managing my symptoms," The titles used are not indicative of what they are supposed to do For example, "monitoring and interaction" is better than "satisfaction measurement". Persian and English words are used in the title of the application. In the section of the medical certificate, under the colonoscopy preparation program, view the program, add a new form, the title of adding a new form is wrong, and the title of adding a new program, should be used instead. In the medical certificate section, add a new form, the title of adding a new form is wrong, and the title of adding a new program, should be used instead. 	1.2 1.6 1.8 1.6 2 1.4 2.2 3 1.6 2.8 1.8 1.4 1.6 1.2 1 1.2 1	Cosmetic problem Minor problem Minor problem Cosmetic problem Cosmetic problem Minor problem Minor problem Major problem Major problem Cosmetic problem Cosmetic problem Cosmetic problem Cosmetic problem Cosmetic problem Cosmetic problem

Table 4 (continued)

The principle of usability	Expe	ert opi	nions			Problem statement	Average	The severity of the problem
	1	2	3	4	5		degree of intensity	problem
						 BMI calculation part, instead of BMI, its Persian equivalent should be used. In the medical certificate section, under the allergies icon, add drug icon after drug/food allergy: the drug/food allergy title should be used from the beginning instead of the allergies title because it is difficult to remember. The principle of consistency and standards are also not respected because the same words should be used as much as possible throughout the program. In the section of my profile, some check marks should not be ticked at the same time, for example, it is possible to select the recovery and relapse icons at the same time. It is better to use the drop-down menu with values or terms understandable for the patient in the section of my specifications for the type of surgery. In the My Profile section, icons should be placed next to the names. For example, alcohol and cigarettes are far from icons. In the registration section of user information and type of disease, why are ulcerative colitis and unknown options the same? A separate option should be placed 		
Error prevention	4 4	3	2 4	4 3	3	 In the medical certificate section, under the sensitivities icon, the add medicine icon, in the drug/food allergy section, no type of (numerical) data should be allowed to enter. In the medical certificate section, under the icon of my tests, blood and stool tests, only numbers can be entered in the boxes, but letters can also be entered and the system will not cet any errors 	3.2 3.4	Major problem Major problem ajor
Recognition rather than recall	-	-	-	-	-	-	-	-
Flexibility and efficiency of use	3	3	2	2 3	2	 In the "My Support" section, there is a repetition of the information in the "Certificate of Illness, Allergies" section. In the medical certificate section, under the colo- noscopy preparation program icon, add a new form, on the edit page of the personal preparation program, the cancel option does not work. For all symptoms, you could have used the all option so that the user does not have to select all options. 	2.6	Major problem
Aesthetic and minimalist design	1 1 2 1 2 2 2 2 2 1 2	2 1 2 2 2 2 2 1 2 1 2 1 2 1 1 2 2 1	1 2 1 1 2 1 3 2 1 1 2 1 1 2	2 1 1 2 1 2 2 1 1 2 1 1 2 1	1 1 1 1 1 1 1 1 1 1 1 1 1 1	 In the Terms and Conditions section, the font color of my IBD Associate is illegible in the About Us section. In the 'drug information' section on the medical certifi- cate page, the icons are not designed properly and are not uniform. Why two items are designed horizontally and two items are designed vertically. Why are different bolts used? In the "Nonitoring and managing my symptoms" sec- tion, the "Psychological monitoring" section is not prop- erly designed, the sentences are covering the icons . In the "Monitoring. Training" design is not suitable, sentences are covered by icons. In the section about us, we encountered long texts. In the medical certificate section, under the colonos- copy preparation program, some items have no writing and only a dash is used. In addition to the fonts, the layout is completely irregular. The arrangement of information in the medical certifi- cate section is not good. On what basis were the colors chosen? Why are two parts green and the rest orange? 	1.4 1 1.4 1.4 1.4 1.4 1.4 1.6 1.6 1.4 1.4 1.4 1.4	Cosmetic problem Cosmetic problem CosmeticProblem CosmeticProblem CosmeticProblem Minor problem Minor problem Cosmetic problem Cosmetic problem Cosmetic problem Cosmetic problem Cosmetic problem

The principle of usability		ert op	inions			Problem statement	Average	The severity of the
		1 2 3 4 5			5		degree of intensity	problem
						 In the medical certificate section, under the icon of my status, at the bottom of the screen, I noticed that there is no reason for the message. In the medical certificate section, under the icon of my status, the fonts are in such a way that they are removed from the page. In addition to the fonts, the layout is completely irregular. Aesthetic aspects are not respected in my profile. For example, the extraintestinal status should be known and it should be clear that the values below are related to it. In the My Profile section, bold should be used to identify and separate different status types. What is the score on the main page on the top left for? It has no function. General error: In various parts of the program, the date is mentioned for no reason. There is no need to mention the date and additional information is placed on the page, for example, in the section "General illegal drugs" 		
Error identification, diagnosis, and recovery	-	-	-	-	-	-	-	-
Help and documentation	3 1	3 2	3 1	3 2	1 1	 The guide placed in the system was not practical and the information needed to use the system was not included in this section. The guide should guide the user in a hierarchical and step-by-step manner. 	2.6 1.4	Major problem Cosmetic problem

instructional development is frequently described by the five stages of the ADDIE model, which stand for Analysis, Design, Development, Implementation, and Evaluation [82, 83]. This model aims to create instructional designs and learning resources more effectively and efficiently. It can also apply to the development of learning strategies, learning methods, media, and instructional materials, among other types of products [84, 85].

A comprehensive study of challenges in mobile applications for self-management in patients with IBD in 2018 revealed that only 6% of smartphone users used mobile applications for disease management and self-education [38]. Hence, the low usage of certain systems may be for several reasons, such as unattractive design, poor user interaction, and, most importantly, insufficient understanding of the needs of patients with IBD. A review emphasized the challenges faced by mobile applications for self-management of IBD patients, showing that a minimal number of smartphone users among IBD patients used mobile applications for disease management and education [38].

Therefore, the following were considered in designing this application: a precise recognition of patient needs, use of strategies to enhance attractiveness, and increased adherence to application through gamification based on the Sukr framework. The study outlines

Table 5 Experts' summary opinions of the prototype MY IBD Buddy application

Questions	Expert opinions	Research team decisions
(1) Do you think this application is easy to use?	All the experts said that the program is easy to use. Two of the experts believed that although it is simple, there is a need for basic training regarding the program.	An educational video was developed on how the application works and a brochure was developed as a guide for the operation of application.
(2) Do you pay attention to an aspect that needs to be improved forever?	In general, all experts were satisfied with the application, but they offered sug- gestions to improve it. The main suggestions was to change the menu titles, arrange the edu- cational content, and modify the appearance of content presented in the mental health section.	The titles and order of the menus were modified. The order of presentation of educational content changed. A separate section for mental health training and relaxation techniques was designed in paral- lel with self-management training. Some animations were modified again.
(3) Was the application well organized on the screen?	Some forms were not set up well.	All forms were reconfigured to display properly on all mobile phones.
(4) Do you think this application covers all relevant content for self-management? _	All experts were in full agreement.	

Specialty	N	Duration of work experiences (years)			
		<10	10–15	>15	
Medical Informatics specialists	2	0	1	1	
Gastroenterologists	2	0	0	2	
Psychology Faculty Member	1			1	
Total	5	0	1	4	

the development process of an application aimed at teaching psychological aspects such as stress and anxiety control, to monitor patient physical and mental status. The educational content of this program has been developed and validated by the research team [50]. Modules for monitoring physical and mental status and reporting were included in the program, acknowledging the broad range of issues related to IBD in each individual [86–88].

The monitoring module focuses on stress and depression, quality of life, knowledge, and disease activity to identify the status of IBD. The research emphasizes the importance of providing accurate, appropriate, and sufficient information, considering different formats such as video, audio, and text in the educational module, and incorporating gamification techniques to enhance motivation, engagement, and user satisfaction.

The development process also involved a multidisciplinary team of health experts, medical informatics specialists, and IBD patients. The application, named "MY IBD Buddy," was developed based on the ADDIE instructional design model and the Sukr gamification framework. The evaluation results were promising, proving the validity, reliability and usability of the proposed application.

Moreover, the present study highlights the collaborative development process with a multidisciplinary team and patients, considering their needs and expectations. A lack of user and healthcare professional participation in developing digital systems in healthcare has been perceived as a limitation. The study attempts to include multimedia content in mobile applications and underscore the importance of integrating gamification to enhance user motivation and satisfaction.

The usability evaluation of MY IBD Buddy application was done by usability testing experts and the target

The principle of applicability		(pei Dini	rt ons			Problem statement	Average degree of	The severity of the problem
	1	2	3	4	5	in	intensity	
Visibility of system status	2	2	2	2	2	"Your progress" icon does not change after using different parts.	2	Minor problem
Match between system and the real world	-	-	-	-	-	-	-	-
User control and freedom	-	-	-	-	-	-	-	-
Consistency and standards	1 1	1 2	1 3	2 2	2 2	•The icons used for height and weight are unconventional and unusable, if you need to decrease or increase, you should use an icon like +, •In this part, the form used is not expressive and the user does not understand how to apply his opinion. It is better to use a range of one to five that is illustrative.	1.4 2	Cosmetic problem Minor problem
Error prevention	2	2	3	3	3	The lock symbol used is inappropriately placed and the user does not notice it. It is better to be on the left side.	2.6	Major problem
Recognition rather than recall	-	-	-	-	-	-	-	-
Flexibility and efficiency of use	3	2	2	2	3	Repetitive headings are used in the program, for example the sections of my experiments and sensitivities are repeated in different sections. While the function of these parts is different. It is bet- ter, for example, to change the title of the sensitivi- ties section in my status section to view sensitivities.	2.4	Minor problem
Aesthetic and minimalist design	2	1	1	1	1	The phrase "chapter number" is unnecessary information that is displayed on the screen and it is not clear what it is for.	1.4	Cosmetic problem
Error identification, diagnosis, and recovery	-	-	-	-	-	-	-	-
Help and documentation	-	-	-	-	-	-	-	-

Table 7 Exploratory evaluation scoring of MY IBD Buddy user interface based on Nielsen principles (beta)



Nielsen heuristics Evaluation

Fig. 5 MY IBD Buddy user interface evaluation based on Nielsen's alpha and beta principles

Average system usability score



Average system usability score



Fig. 7 System Usability Score (SUS)

population in three stages. The target group provided an average score of 80.68 to the system, surpassing the minimum score of 68 indicating a good satisfaction with the application on a ranking scale [89]. Participants' feedback raised concerns that are easily soluble to enhance the usability of MY IBD Buddy [90]. Developers should consider participant feedback to increase the usability of a smartphone application. High usability contributes to the increased or decreased productivity, satisfaction, and

Table 8 Demographic characteristics of the participants

Characteristics	Mean (standard deviation) or
	Number (%)
Age (years)	38.5 (SD=11.94)
Sex	
Man	11 (50%)
Female	11 (50%)
Level of Education	
No university education	6 (27.27%)
Bachelor of Science	7 (31.82%)
Master of Science	6 (27.27%)
PHD	3 (13.64%)
Туре В	
Crohn's	11 (50%)
Ulcerative colitis	11 (50%)
Current state of the disease	
Active	10 (45.45%)
Inactive	12 (54.55%)
Duration of disease	11.78 (SD=6.70)

acceptance by end-users. The development stages in the study successfully increased the satisfaction and acceptance of end-users, resulting in a usability score above the average for the initial prototype.

The OshiHealth app is designed for patients with gastroesophageal reflux disorder (GERD), celiac disease, IBD, irritable bowel syndrome, and other chronic gastrointestinal (GI) disorders. Through the application, users can message and have virtual visits to the Oshi Health team. In addition to using weekly surveys to monitor their IBD symptoms and well-being, users also integrate data from wearables and fitness devices and get push notifications to help them stay on track with their goals [91]. The Crohn's & Colitis Foundation created the app GI Buddy, which lets users keep track of their food intake, activity, medications, and IBD symptoms. It also lets users schedule reminders for their doctor's appointments. Moreover, there is a community feature that allows users to interact with other IBD patients [91].

Users of the paid symptom tracking app Colitis Diary can log their bowel movements, symptoms, and potential triggers using a calendar format, sleep, weather, nutrition, vital signs, drugs, medical events and tests/procedures, exercise, and free text notes. Indeed, there is a trending module that shows to users the triggers and contributing factors to their symptoms [91]. ColitisTracker is a free substitute that tracks symptoms, prescriptions, and free text notes in a calendar format. MyIBDCare facilitates the tracking of bowel movements, appointments, flare-ups, symptoms, and medications. It offers courses for education on sleep, medication, and exercise, as well as a newsfeed about IBD [91, 92].

Another study sought to evaluate a newly developed 16-week digital health program for patients with IBD, examining participant engagement, preliminary effectiveness, and the impact on participants' energy levels (fatigue), stress, and sleep quality. The developers indicate that completing treatment may significantly improve patients' reported stress and energy levels in a real-world context and support the viability of a digital health program for IBD patients [92]. As a novel application, IBDMonitor enables patients to meticulously document important information, including medication use, symptoms, lifestyle, and physiological, pathological, and everyday events. These patient-generated reports are made available to medical professionals in real-time, allowing them to make timely treatment adjustments [93].

Induction and maintenance of remission, symptom control, and inflammation management are the main goals of IBD treatment [93]. Patients who used digital interventions reported feeling more secure about their condition, more involved in their own care plans, and better cared for outside the hospital or clinical setting, according to a study on the effects of smartphone interventions on long-term health management of chronic diseases [92]. Also, digital interventions have been linked to increased convenience, productivity, and efficiency as well as decreased health care costs [92]. Engaging patients in their own healthcare is made possible by mobile applications through a variety of ways including virtual visits, care team messaging, surveys and questionnaires, symptom tracking and analysis, data integration from wearable devices, push notifications for reminders, forums, a community platform, newsfeed for research updates, educational modules, and public restroom locators [91].

A user-friendly interface, survey fatigue, and careful analysis of the most pertinent data points are just a few of the many factors that should be taken into account in designing any mobile application or technology platform [91]. Many web-based and smartphone applications have been created for mHealth at this time. Some of these have even undergone clinical research, but their use is still limited and irregular. To better understand how mobile health affects clinical outcomes and to determine the factors influencing the use of mobile health in our healthcare systems, more research or thorough understanding is required which justifies the current investigation.

Gamification concepts, also known as serious games, are a major trend in the development of mobile learning apps. These concepts use game and enjoyable elements to motivate and entice learners. The main goal of a serious game is to help the player achieve a learning goal in an enjoyable way, with the learner having the locus of control [91]. Gamification is a growing aspect of mHealth applications that has only recently been used to enhance self-management practices [93]. One emerging innovative practice is the use of gamification design principles to mHealth applications. Therefore, it is essential to talk about design considerations. The effectiveness of mHealth applications that use gamification mechanics is currently not well supported by empirical data.

Limitations

Despite the strengths of the present study, several limitations should be acknowledged. Although, according to some research, this ample size in usability testing can detect over 80% of issues, the number of participants in this evaluation may still need to be increased. Additionally, the follow-up duration might need to be increased due to the great variation in patients' physical and mental conditions. Therefore, future research is recommended to consider a larger sample size and a longer follow-up. Furthermore, the current version of application has been developed only in Persian and for the Android operating system, excluding iPhone users. It is suggested that future application versions be developed to include support the iPhone platform and in potentially other languages to make it better available to a broader range of users.

Recommendations

The long-term use of "My IBD Buddy" app is recommended for routine disease management and evaluation of its effectiveness in clinical and non-clinical outcomes is currently designed as a protocol [94]. Additionally, providing an English version and the possibility of using the app by iPhone users should be considered in future versions.

Conclusion

The present study detailed on developing and evaluating a self-management mobile application, My IBD Buddy, using gamification techniques for patients with IBD. The findings showed that employing a standalone mobile application based on a standard educational model with gamification techniques can enhance patient self-efficacy and self-management skills. Moreover, the design and development of My IBD Buddy can serve as a practical and realistic model for the development of mobile health applications. The application, developed in Persian, proved satisfactory to users and increased their self-management awareness and daily condition control. User satisfaction correlates positively with meeting the needs of patients with IBD and customizing programs. The complex characteristic of IBD and the diverse range of symptoms in each individual make it impossible to develop a comprehensive program to cover all aspects of IBD self-management. Thus, developing specific applications for different aspects

of IBD self-management or considering a range of capability levels in patients with IBD may be a more practical and constructive strategy. Encouraging individuals with IBD to use self-management programs can be achieved through tailored app development for various dimensions of IBD self-management. As the application development evolves, the application of interest can serve as a starting point for future research to improve self-management programs for patients with IBD.

Supplementary Information

The online version contains supplementary material available at https://doi. org/10.1186/s12911-024-02842-3.

Supplementary Material 1.

Authors' contributions

NN, SN, MF,AB,JSH,SE and HT conceptualized, designed, and conducted the studysis. NN drafted the manuscript with signifcant intellectual input from SN, and HT assisted with revising the article. All authors approved the fnal version of the manuscript.

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Data availability

The datasets utilized and/or analyzed in the present study can be obtained from the corresponding author upon making a reasonable request.

Declarations

Ethics approval and consent to participate

This study followed the Helsinki Declaration and Ethics Publication on Committee (COPE). In addition, the present study was approved by the research ethics committee of the Mashhad University of Medical Sciences (#IR.MUMS. REC.1400.230). The researcher obtained all participants' verbal and written informed consent before conducting the study. It is important for participants to feel comfortable and secure when participating in a study. Ensuring that their data are exclusively analyzed by the researchers and that they retain the right to withdraw from the study at any time is a great way to establish trust and maintain ethical research practices.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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