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Development and evaluation of a shared decision-making system for choosing the type of bariatric surgery

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Abstract

Introduction Obesity is a multifactorial disease resulting from various environmental, genetic, and metabolic factors, affecting a large portion of the population. One of the most effective treatments for severe obesity is bariatric surgery. This research aims to develop a shared decision-making system that facilitates the selection of the appropriate type of bariatric surgery.

Method In this research, we designed and developed a prototype of a shared decision-making system to aid in choosing the type of bariatric surgery through three steps: a) identifying data requirements from a literature review, b) designing interfaces and prototyping, and c) conducting a usability evaluation.

Results Through a literature review of articles, books, and interviews with ten selected patients, the necessary clinical data and educational topics were identified and confirmed by nine surgeons. A prototype was developed using the web application "Figma." We also analyzed the prototype using heuristic evaluation; "helping users understand and recover from errors" and "confidentiality" had the highest degrees of problem severity, with scores of 3.3 and 3.5, respectively.

Conclusion The developed prototype demonstrated an acceptable level of usability. This system can facilitate shared decision-making and help structure education for patients seeking bariatric surgery.

Keywords Bariatric surgery, Prototype, SDM, Shared decision-making, Usability evaluation

Introduction

In the past decade, obesity has significantly increased and has become one of the leading causes of chronic diseases [1]. Obesity is characterized by an increase in body fat mass, both in terms of number and volume [2]. This condition is typically measured using body mass index (BMI) [3]. According to the World Health Organization (WHO) standards, obesity is defined as a BMI ≥ 30 [4]. The latest statistics published by the World Obesity Observatory (WOO) as of August 2021 show that approximately 22.7% of Iran's population is obese. Interestingly, these statistics indicate that 19.98% of Iranian men and 33.47% of Iranian women rank 87th and 41st, respectively, among the most affected by obesity [5]. Obesity is associated with numerous diseases that can reduce life expectancy by 5 to 20 years [3] and has profound health, social, and economic consequences [6].

Traditional weight loss methods, such as lifestyle changes and medical intervention, usually lead to poor outcomes in weight reduction and remission of

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metabolic comorbidities [7, 8]. When these conservative methods fail to reduce body fat mass or improve obesity-related diseases, bariatric surgeries are the best available options [9]. Bariatric surgery is considered the first choice for individuals with a BMI ≥ 40 when other treatment methods are ineffective or for those with a BMI ≥ 35 with at least one metabolic comorbidity [10]. Gastric bypass, sleeve gastrectomy, and adjustable gastric banding are the most widely used procedures.

All surgical methods significantly differ in procedure, side effects, and benefits. Factors such as the treatment goal (whether weight loss or glycemic control), gastroesophageal reflux, nutrient deficiencies, patient preferences, and the surgeon's experience play a key role in choosing the surgical method [11]. This is why physicians select the most appropriate type of surgery for the patient after conducting numerous clinical and para-clinical evaluations. According to the recommendations of the American Society of Gastrointestinal Endoscopy and the European Society of Gastrointestinal Endoscopy, the choice of treatment method should be personalized for each patient [10]. Patients should be involved in their care and treatment decisions, alongside the medical team, to ensure they choose the option most suitable for them at that time [12]. Since selecting the best weight loss intervention requires the mutual participation of both patient and physician, the shared decision-making (SDM) approach seems to be the most appropriate method.

This approach is an interactive method in which the patient and the physician go through all stages of the decision-making process together, using clinical protocols to simultaneously reach appropriate treatment options while considering the patient's treatment preferences [13]. SDM is most suitable when there is more than one reasonable treatment option or when none of the options have clear advantages, and the harms and benefits of each method affect the patient in completely different ways [14]. The nature of SDM provides an ideal platform for utilizing clinical decision support systems. Medical decision support systems are software programs that assist physicians (or patients) in making clinical decisions [15]. These systems are designed to help those involved in making decisions about treatment options by improving collaboration among patients, providers, and other healthcare professionals [16]. This is achieved by clarifying the available options, providing evidence-based information about their advantages and disadvantages, and helping patients understand their preferences regarding outcomes [17].

The result of the current research is an SDM system that facilitates the process of selecting the most appropriate surgical intervention with the help of the patient through a question-and-answer format, creating an unambiguous perspective for the patient. In addition to speeding up the decision-making process, this system's mission is to educate patients and inform them about the advantages and disadvantages of each option while addressing unscientific misconceptions patients may have about surgeries. Physicians will also receive information such as family history, current diseases and medications, clinical evaluation results, eating habits, patient preferences, and more through access to the data entered into each patient's account. This will allow the patient and physician to have an informed consultation, in which the patient will possess sufficient knowledge about surgical options, and the physician will have the answers to many key questions that influence the choice of surgery, presented in the form of a report.

Methods

This study comprises three phases:

Phase I: identify data and system requirements

The Requirements Engineering process is a critical step in the software development life cycle, as it ensures that the software system being developed meets the needs and expectations of stakeholders and is delivered on time, within budget, and at the required quality. Requirements engineering refers to the systematic and rigorous approach to defining, developing, and verifying the requirements for a software system. The main types of software requirements can be classified into two categories: functional requirements and non-functional requirements [18].

Functional requirements refer to the demands of end users, outlining the basic capabilities the system should provide. These can include calculations, data manipulation, business processes, user interactions, or any other specific functionalities that define what the system is intended to do. These requirements are explicitly stated by users and are visible in the final product, in contrast to non-functional requirements.

Non-functional requirements are quality constraints that the system must satisfy according to the project specifications. Unlike functional requirements, non-functional requirements do not pertain to system functionality; instead, they define how the system should perform. The degree to which these factors are prioritized and implemented varies from project to project [19].

We first conducted comprehensive searches through three databases—Scopus, PubMed, and Web of Science—using keywords and MeSH terms. The first search was focused on identifying functional requirements and patient information needs to facilitate informed and

active participation in decision-making. The second search aimed to identify functional and non-functional requirements from related technological innovations. The final output from these selected studies was a consolidated list of functional and non-functional requirements. The search strategies used in this study are detailed in Tables 1 and 2, and Fig. 1 presents the PRISMA diagram summarizing the search process.

We reviewed widely used and valid textbooks and guidelines in the next step. Among the most important guidelines reviewed were the Practical Guide of the European Association for Endoscopic Surgery [20], the textbook published by the American Society of Metabolic and Bariatric Surgery [21], and the guideline published by the Society of American Gastrointestinal and Endoscopic Surgeons [22] and other guidelines [23, 24]. Additionally, we examined the web-based system recently launched in Iran, known generally as the "Obesity Database," which aims to collect clinical patient data for statistical purposes. The results from these three steps were used to design a checklist, which served as a tool to engage surgeons in selecting the system requirements.

After designing the checklist and determining the importance and necessity of using the extracted data in the system, it was presented to a group of surgeons and specialists in this field. Due to the limited number of surgeons specializing in bariatric surgery and considering factors such as their willingness to participate and availability, 9 surgeons were selected through purposive sampling. It should be noted that the participating surgeons were chosen from both private and government clinics in Shiraz.

Using the Delphi technique, the surgeons were asked to validate each data element and provide their opinions on the impact of each element or educational title on decision-making. The checklist was designed in eight sections and a 5-point Likert scale ranging from 1 to 5, where 5 represented "completely agree" and 1 represented "completely disagree". Additionally, at the end of each section, a free text box was considered for recording any new experts' suggestions. Experts were invited to cooperate and participate in the study through email. checklists were designed using an online questionnaire creation tool (@Porsline) and its link was sent to experts along with the original file in Word and PDF format. The response time to the checklists and sending them was considered to be a maximum of one month and two weeks after sending them, the response time was reminded to the participants. Based on the statistician's recommendation, to reach a consensus regarding the items of the checklists, we used a consensus agreement level of 75%. Consensus statements between experts can be effective by making recommendations in some clinical topics where there are no strong evidence-based findings.

Table 1 First search strategy: patient's information needs

Database	Search strategies
Scopus	TITLE(patient inform* OR patient educat* OR patient teach*) AND TITLE(gastroplasty OR sleeve OR bariatric OR "gastric banding" OR "gastric bypass" OR "obesity surgery")
PubMed	(((patient inform*[Title]) OR (patient educat*[Title]) OR (patient teach*[Title])) AND ((((((obesity surgery[Title]) OR (gastric bypass[Title])) OR (gastroplasty[Title])) OR (bariatric[Title])) OR (gastric banding[Title])) OR (sleeve[Title])))
Web of Science	(patient inform* OR patient educat* OR patient teach*) (Title) and (bariatric OR gastroplasty OR sleeve OR "gastric bypass" OR "obesity surgery" OR "gastric banding") (Title)

Table 2 Second search strategy: functional and non-functional requirements pre-operative surgery from related technological innovations

Databases	Search strategies
Scopus	TITLE("mobile health" OR mHealth OR VR OR CDSS OR CPOE OR smart* OR tele* OR "mobile app*" OR "information system" OR "clinical decision support system" OR "decision support*" OR "computerized physician order entry" OR "virtual reality" OR technology OR shared decision*) AND TITLE("obesity surgery" OR "gastric bypass" OR gastroplasty OR bariatric OR "gastric banding" OR sleeve(
PubMed	))((((()))))))))))mHealth[Title]) OR ("mobile health"[Title])) OR (smart*[Title])) OR (tele*[Title])) OR (mobile app*[Title])) OR (information system[Title])) OR (CDSS[Title])) OR (decision support*[Title])) OR (CPOE[Title])) OR (clinical decision support system [Title])) OR (decision support* [Title])) OR (computerized physician order entry [Title])) OR (VR[Title])) OR (virtual reality [Title])) OR (technology[Title])) OR (shared decision*[Title])) AND (((((obesity surgery[Title]) OR (gastric bypass[Title])) OR (gastroplasty[Title])) OR (bariatric[Title])) OR (gastric banding[Title]) OR (sleeve[Title])))
Web of Science	"mobile health" (Title) or mHealth (Title) or VR (Title) or CDSS (Title) or CPOE (Title) or smart* (Title) or tele* (Title) or "mobile app*" (Title) or "information system" (Title) or "clinical decision support system" (Title) or "decision support*" (Title) or "computerized physician order entry" (Title) or "virtual reality" (Title) or technology (Title) or "shared decision*" (Title) (Title) and "obesity surgery" (Title) or "gastric bypass" (Title) or gastroplasty (Title) or bariatric (Title) or "gastric banding" (Title) or sleeve (Title) (Title)

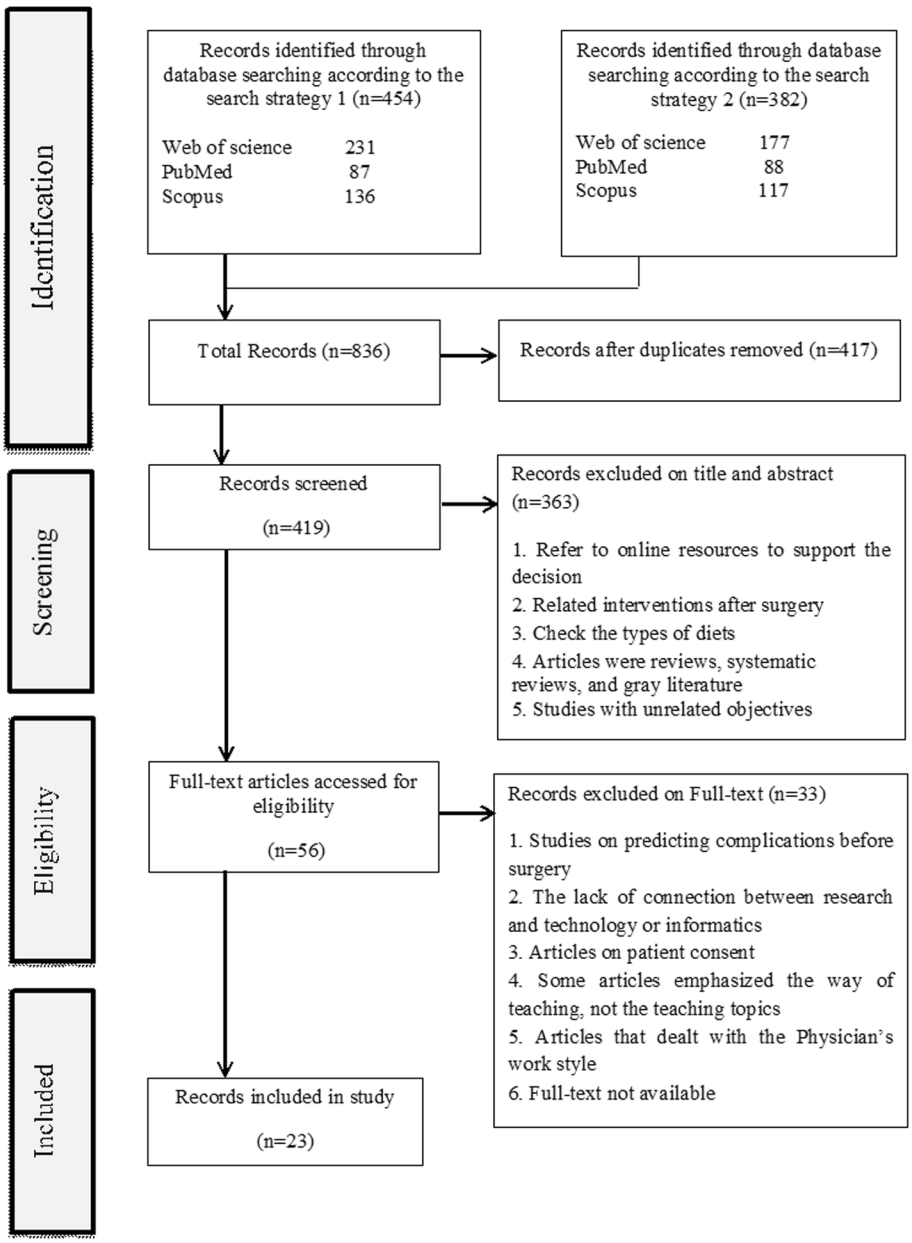

Fig.1 PRISMA diagram of search strategies

Semi-structured interviews were conducted to identify better the information needs of patients, who are one of the main stakeholders. Data saturation was reached after 10 interviews, and no new data were obtained from the 11th interview. It is important to note that interviewees' statements were recorded after obtaining informed consent. No fees were charged for their participation, their identity information was kept confidential, and after transcribing and analyzing the interview content, the audio recordings were deleted from the device's memory.

Phase II: interface design and prototyping

Using the data obtained and confirmed in the first stage, the user interfaces and the interactions between each user and the system were determined. Unified Modeling Language (UML) was used to visualize the behavior and structure of the system. In this study, after extracting the important scenarios for system operations, we selected two diagrams: the use-case diagram and the sequence diagram. SAP PowerDesigner version 16.7 software was used to create these diagrams.

After finalizing the use-case and sequence diagrams, the prototype was developed using the web-based program "Figma." This system includes user interfaces for the administrator, physician, and patient.

Phase III: usability evaluation

Heuristic evaluation is one of the most common methods used to assess the usability of information systems. Due to its low cost and simplicity, this approach is often used as a usability evaluation method. It is typically based on a set of heuristics derived from the principles outlined by Nielsen to identify potential software usability problems. A severity score, ranging from 0 to 4, is assigned to each system issue to indicate its intensity. This method involves the collaboration of a group of evaluators (typically 3 to 5) who review the user interface and assess its compliance with 13 predetermined standard heuristics principles [25]. We employed a shortened version of heuristic principles, consisting of 13 principles and 54 items [26].

In this study, the opinions of three evaluators (two with MSc degrees in medical informatics and one with an MSc in computer engineering) with experience in software system usability evaluation were used. Initially, the evaluators were provided with a checklist of heuristic principles and access to an executable prototype on a mobile phone. Each evaluator independently reviewed the prototype. Following this, a virtual meeting was held for the evaluators to share their thoughts, exchange opinions, and reach a consensus on identifying the final list of system problems.

In the next step, each evaluator assigned a severity level to the identified problems using a 5-point scale. The average scores assigned to each usability issue indicated the severity of the problem [27].

Result

Phase I: identifying data and system requirements

Before the design of this system, the surgeon was the sole decision-maker, relying on clinical information to choose the type of surgery. However, the patient also plays a crucial role in this decision, and the best choice should be made collaboratively. Therefore, to determine the educational needs of patients in order to participate in decision-making, both the physician's experience and the patients' opinions are critical. Consequently, the checklist prepared to gather physicians' opinions includes clinical and educational sections. Finally, the educational topics approved by the physicians were combined with the results of patient interviews and integrated into the system design.

The researcher-developed checklist, presented to surgeons, included 83 data elements classified into 8 main categories during the focus group meeting, following the opinions of the research team's professors and experts participating in the Delphi process. The first three categories—"socio-demographic characteristics," "clinical history," and "lifestyle"—gathered essential clinical data necessary for making decisions about the type of surgery during the interaction between the patient and the system. Information that patients need to participate in the decision-making process consciously is organized under the "educational modules" category, which consists of four main subcategories: "general information," "pre-operation clinical evaluations," "pre-operation information," and "post-operation information." For educational content that was essential for patients but did not fit into the other subcategories, a "frequently asked questions" category was created. Additionally, the final three categories—"create reports," "security and confidentiality," and "joining the forum"—were assigned to the system's features. A summary of the checklist content is shown in Table 3, and the full version is provided in Appendix 1.

The purposively selected sample of surgeons in this study included 9 male surgeons, all of whom had a fellowship in bariatric or laparoscopic surgery, with an average of approximately seven years of experience in bariatric surgery. According to the results of the surgeons' evaluations, all the data elements on the checklist met the required threshold in the first round of Delphi. Therefore, there was no need to conduct a second round of Delphi, and this round was not performed.

The patients interviewed included 9 women and 1 man, with an average age of 30. The time elapsed since their surgeries ranged from one week to two years. Based on the opinions of the research team professors and experts participating in the Delphi method, all the information provided by the patients during their interviews was organized into three categories: "general information,"

Table 3 Check list content summery

Categories	Number of items
Socio-demographic	10
Medical history	34
Current lifestyle	8
Educational module - Basic information - Pre-operation clinical evaluation - Pre-operation info - Post-operation info	19
Most frequently asked questions	6
Create report	2
Security and confidentiality	3
Joining the forum	1

"pre-operation information," and "post-operation information," which are detailed in Tables 4, 5 and 6.

Surgical complications, part of the general information category, were the most important concerns raised by the interviewees. Complications such as the effect of surgery on pregnancy, dumping syndrome, physical weakness, depression, hair loss, gallstones, skin damage, weight regain and the need for re-surgery, vitamin and mineral deficiencies, and the effects of surgery on memory were frequently mentioned by patients. Among these, the incidence of dumping syndrome (60%) and weight regain (40%) were the most frequently noted.

Table 4 General information needs (from patient interviews)

Title	Frequency
1. Complications of surgery	100%
2. Knowing the types of surgery	80%
3. Checkups and periodical references	70%
4. Complications of obesity	50%
5. Weight loss process after surgery	50%
6. Advantages of surgery	40%
7. The cause of obesity	30%
8. Clinical evaluations before surgery	30%
9. Comparison of types of surgery	20%
10. Eligible persons	10%

Table 5 Pre-operation information needs (from patient interviews)

Title	Frequency
1. Smoking	80%
2. Consumption of alcoholic beverages	80%
3. Need to lose weight	40%

Table 6 Post-operation information needs (from patient interviews)

Title	Frequency
1. Diet after surgery	100%
2. Appetite after surgery	40%
3. Physical activity	40%
4. Use of nutritional supplements	30%
5. Lifestyle	30%
6. Alcohol consumption	30%
7. Smoking	30%
8. Stop losing weight	20%
9. Will and motivation	10%

Phase II: interface design and prototyping

UML diagrams were created, system details were determined, and the prototype was developed using a web application called "Figma." The system features three user interfaces: patient, physician, and system manager. The patient user interface includes the following sections: *User Account* (containing the socio-demographic characteristics of the patients), *Medical Record* (comprising the patient's clinical data and history), *Educational Modules* (including "What I Need to Know," pre- and post-surgery information, and pre-surgery clinical evaluations), *Help File* (guidelines for using the system), *Upload Section* (for uploading laboratory test images), *News and Articles*, and *Discussion Group* (for exchanging experiences with others). The patient completes the first two sections, User Account and Medical Record. Upon their first entry into the system, patients must fill in these two sections to provide the necessary data. Until these sections are fully completed, the patient's access to educational content and other system features remains locked. Only after completing the required patient information will the patient be able to access the remaining system features.

The *login page* and *main menu* of the patient interface are shown in Figs. 2 and 3.

The physician will have access to the clinical information and personal details registered by the patient during their first visit to the program, along with the images of clinical evaluations (e.g., laboratory tests, endoscopy, ultrasound) uploaded by the patient. Additionally, the physician can extract statistical reports based on various criteria from patient referrals. The physician can also join the discussion group to monitor the information exchanged to facilitate oversight.

The system manager has functionalities that include deleting, adding, or editing user accounts or basic information and updating the educational content. The main menus of the admin and physician user interfaces are shown in Figs. 4 and 5.

Phase III: usability evaluation

In total, 15 of the 54 items mentioned in the heuristic evaluation checklist were identified as system problems. Among these, all three evaluators noted 11 items, and at least two evaluators recognized three principles as problematic. Table 7 shows the problems identified by the evaluators, along with the average degree of severity and deterioration attributed to each principle. Among the identified issues, the most critical usability concerns were "Helping users understand and recover from errors" and "Confidentiality".

Fig. 2 Patient user interface (1)

Discussion

In this research, we developed and evaluated the prototype using heuristic evaluation principles after extracting the system's information requirements, drawing the use-case and sequence diagrams, and determining the system's functional details. Aside from the three principles of "error prevention," "helping users understand and recover from errors," and "confidentiality," the other aspects were either problem-free or had issues of very low severity.

Providing clinical services remotely to bariatric surgery candidates can offer significant benefits, such as saving time, money, and travel. Additionally, numerous studies indicate that patients are generally satisfied with these interventions [28–30]. Improved surgical outcomes and positive behavioral changes post-surgery are other benefits of offering remote counseling services before bariatric surgery [29–31]. It should be noted that, with the decreasing age of bariatric surgery applicants, providing educational materials online via mobile applications (as opposed to face-to-face counseling) can help engage more young people [31].

Many studies have focused on enabling the selection of candidates for bariatric surgery, determining the type of surgery, or conducting multi-specialty consultations remotely, often utilizing voice or video calls to achieve these goals.

Yi-Chi-Lee et al. conducted a study closely related to the present research, as the primary function of their shared decision-making system was similar to the software in question. They developed a program to assist in selecting the type of surgery, which facilitates active participation in decision-making by providing definitions of obesity and related diseases, treatment plans, possible surgical options, weight loss programs, surgical conditions, and post-operative eating habits [13].

The most significant difference is that their application primarily emphasizes providing information to the patient rather than gathering it, with clinical data exchange mainly occurring during in-person meetings

Fig. 3 Patient user interface (2)

Fig. 4 Admin user interface

with the physician. In contrast, the current software allows for two-way data exchange, enabling the patient and the physician to access the necessary information before the initial face-to-face meeting. This approach supports informed participation in decision-making and provides the clinical guidance required. The program also aids patients in better understanding their preferences and what is important to them, analyzing the advantages and disadvantages of each surgery in light of these preferences, and ultimately supporting them in making informed decisions.

Some similar studies have concentrated on specific areas of pre-surgery preparation, often providing more in-depth and detailed recommendations. In contrast,

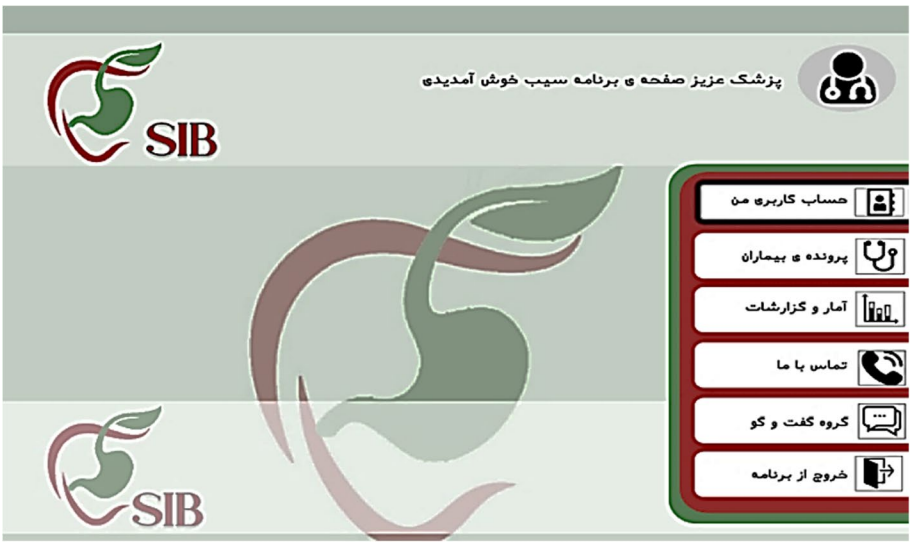

Fig. 5 Physician user interface

Table 7 Usability evaluation result

The title of the heuristic principles	Three evaluators	Tow evaluators	One evaluator	Total problems	The average degree of intensity	Aggravation of the problem
1. Clarity of system status	0	1	0	1	1	Cosmetic
2. Correspondence between the system and the real world	1	0	0	1	0.3	Cosmetic
3. User freedom of action and mastery of the system	0	0	0	0	0	No problem
4. Compliance with uniformity and standards	0	1	0	1	1	Cosmetic
5. Error prevention	3	0	0	3	3	Major
6. Identifying instead of remembering	0	0	0	0	0	No problem
7. Flexibility and simple design	0	0	1	1	0.6	Cosmetic
8. Aesthetic aspects and simple design	1	0	0	1	1	Cosmetic
9. Helping users understand how to diagnose and recover from errors	4	0	0	4	3.3	Catastrophe
10. Guidance and documentation	0	1	0	1	1	Cosmetic
11. Skills	0	0	0	0	0	No problem
12. Pleasant and respectful interaction with the user	0	0	0	0	0	No problem
13. Confidentiality	2	0	0	2	3.5	Catastrophe
Total	11	3	1	15		No problem

our research addresses all areas necessary for the patient more generally, deferring referrals to specialists such as nutritionists, psychologists, and physical education experts until after the physician's initial in-person consultation.

In their study, Pierro et al. conducted psychological and nutritional evaluations of bariatric surgery applicants remotely during the COVID-19 era via WhatsApp calls. The main topics of these consultations were weight management before surgery and the management of psychological disorders [32]. Similarly, Baillot et al. focused on physical activity interventions before bariatric surgery. Their program, named Flan, aimed to provide exercise training to patients seeking bariatric surgery to improve quality of life and enhance beliefs in physical activity. This study emphasized precise and detailed training related to physical fitness assessments [33].

Lodewijks et al. focused on the remote counseling and screening of bariatric surgery applicants during COVID-19, utilizing audio and video calls. The factors influencing

their decisions included a range of socio-demographic and clinical data. Additionally, patients received consultations in nutritional psychology and physical therapy remotely. While this approach is similar to the current research regarding the information impacting decision-making, it does not mention any written or structured educational materials. Furthermore, the purpose of this screening is limited to confirming patients' eligibility for surgery rather than selecting the type of surgery [34].

The present software facilitates a two-way exchange of information between the patient and the physician. It offers comprehensive training in various areas, including general information (obesity and its consequences, surgical options, and their respective advantages and disadvantages), specialized information (pre-and post-operative care), and descriptions of clinical processes before surgery. This preparation helps patients feel more equipped for their face-to-face meeting with the physician and aids in making an informed final decision. Furthermore, by collecting socio-demographic and clinical information from the patient and presenting it as a clinical record, the software provides the physician with a clear understanding of the patient's condition before the visit.

Conclusion

In this research, we designed and developed a prototype system that incorporates effective factors in shared decision-making for stakeholders: the physician and the patient. This system facilitates the decision-making process by collecting data from the patient before their in-person meeting with the physician and providing essential information to ensure the patient is well informed about the process they are undergoing. Ultimately, the patient will be able to actively participate in choosing the best surgical option based on their values and preferences, minimizing the need for multiple consultations with specialists or extensive information searches. Physicians can also benefit significantly by reducing the time spent assessing the patient's health status and addressing repetitive questions, streamlining the process of informed decision-making and enhancing efficiency for both parties.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12911-024-02796-6.

Supplementary Material 1: Appendix 1.

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Authors' contributions
SZ, SD, and RR were involved in Conceptualization; SD was involved in data curation, formal analysis, validation, visualization, and writing—original draft; RR contributed to formal analysis, methodology and supervision; SZ was involved in investigation, methodology, writing—original draft, writing—review and editing.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
This study was extracted from an MSc thesis supported financially by the Shiraz University of Medical Sciences (project number: 25699). Ethics approval (IR.SUMS.NUMIMG.REC.1401.031) was obtained from the ethics committee of Shiraz University of Medical Sciences.

Consent for publication
All interview participants signed written consent forms, agreeing that their statements could be published anonymously, ensuring no personal identification could be made.

Competing interests
The authors declare no competing interests.

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