Designing a Mobile Phone Application for Self-Management of Knee and Lumbar Osteoarthritis: A Usability and Feasibility Study

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Abstract

Aim: This study aims to outline the major phases involved in developing a mobile app for self-management of knee and lumbar osteoarthritis.

Method: This developmental research had three phases, including, content selection, application design and development, and evaluation. First, a questionnaire was created based on the literature review, and its content validity index (CVI) and content validity ratio (CVR) were measured by 15 specialists. To approve the contents of the app, the 15 rheumatologists used the Delphi technique. The application was designed using Android programming tools after the content was selected. SQLite was also used to develop a database. Finally, 12 patients evaluated the application's usability through the questionnaire for user interaction satisfaction (QUIS).

Results: Based on the rheumatologists' preferences for information content and format, 45 key data elements were specified in 8 sections. The application was then built, which included six primary modules: medical records, educational information, disease management, record activities, reminders, and reporting. Finally, the application's usability was praised (7.56 out of 9). The application was updated with the necessary improvements based on user feedback following the evaluation.

Conclusion: app evaluating is currently underway to verify the application's usability and feasibility, and its effect on osteoarthritis outcomes linked to pain control and physical activity will be investigated in future studies.

Keywords: Osteoarthritis, Smartphone, Mobile Health, Self-Management, Usability, Feasibility

The global aging population, defined as people aged 65 and older, is continuing to grow as a result of global demographic shifts. The rising population of the elderly, the frequency of chronic diseases, and COVID-19 outbreaks face healthcare systems with a multitude of issues. These problems put pressure on health systems to handle patients effectively, reduce risk factors, and enhance patient outcomes (1, 2).

Chronic diseases are becoming a great burden on healthcare systems, accounting for more than 80% of primary care and 70% of medical emergencies (3). Osteoarthritis is a chronic condition. It is so common that the United Nations has named the first decade of the twenty-first century as the Decade of Bone and Joint Disease on behalf of the World Health Organization (WHO) (4). It is one of the variables that causes pain and disability in adults and the elderly around the world, lowering their quality of life.

Osteoarthritis is becoming increasingly common (5). The most frequent type of this disease is osteoarthritis of the knee and spine (6, 7). This illness is commonly treated with pharmacological and non-pharmacological methods such as weight loss, exercise, diet, and physical therapy (8).

Providing patients with self-management education and physical activity programs are the most effective ways to control the disease (9). Self-management was defined by Fletcher et al.'s study as "an individual's ability to manage symptoms, treatment, and physical and psychological implications of the disease, and make lifestyle modifications necessary to live with a chronic condition." Efficient self-management is defined as the ability to monitor one's situation and influence cognitive, behavioral, and emotional reactions as required to maintain a satisfactory quality of life. Moreover, it concerns constructing a dynamic and continuous self-regulation process (10).

In this regard, with technological advancements, health information technology (HIT) can play an important role in disease management as well as epidemic prevention and control. Mobile health application technologies are the most common among them (11-13). Researchers can now support disease management with a variety of positive changes, including increased knowledge, increased physical activity, short-term weight loss, decreased anxiety, improved self-confidence, emotional well-being, and improved quality of life. They are all possible through the contributions made by smartphones with open architecture (14).

Patients with chronic diseases greatly demand services provided by mobile health apps, especially during pandemics (15). This is because they can learn more about their conditions and take an active role in their treatment by using self-management applications (16).

Accordingly, the authors decided to describe the design, development, and evaluation phases of a new mobile application for enhancing patients' physical activity and self-management in knee and lumbar osteoarthritis in this study. This app is named ASKLO, which stands for application for self-management of knee and lumbar osteoarthritis.

Method

Study design

In this developmental study, a multi-method approach was applied in three phases, including the use of a structured interview and questionnaire:

A- Content Selection

This phase was performed as follows:

1.**Questionnaire design**

A questionnaire based on the literature with eight sections was created. Respondents were asked to complete a series of demographic and background questions in the first part of the questionnaire. The remaining parts included topics such as lifestyle, clinical information, laboratory and radiographic findings, patient training, self-management, and application capabilities.

It also included an open-ended question to look for potential data items. The content validity ratio (CVR) and the content validity index (CVI) were calculated by asking 15 experts in medical informatics, health information management, and rheumatology to score each item to determine the questionnaire's content validity.

The CVR is a scale that measures the importance of an issue and ranges from 1 to 1; a higher number suggests more agreement among panel members. CVR = (Ne – N/2)/(N/2), where Ne is the number of panelists who believe an item is "important" and N is the total number of panelists (17).

CVI is a numerical figure that represents the degree of validity of an instrument as evaluated by experts. Generally, a CVR of at least 0.78 implies that an item or scale is valid (18).

According to the Lawshe table, the minimum acceptable CVR value for a sample of 15 experts is 0.49. The questionnaire was omitted from those questions with a CVR value of less than 0.49. The CVI index had to be at least 0.79 to be considered acceptable, and if it was less than 0.79, the item was eliminated. Cronbach's alpha was used to determine the questionnaire's percentage of reliability (82%).

These calculations were performed with SPSS-20.

2. Delphi technique

Following revisions, the questionnaire was sent to a Delphi expert panel comprised of 15 rheumatologists with more than 5 years of experience. The Delphi technique was used to decide whether or not an item was required. There were five possible attributions for each domain and item (from "very high necessity" with five points to "very low necessity" with one point).

Experts determined mean scores for each item. A mean score of greater than 50% indicated item acceptability, and a mean score of less than 50% indicated item unacceptability. A list of data elements was chosen for use in the app based on the final panel's rating.

B- Design and Development

Several scripts for the application were built after content and functional capabilities were determined, including scenarios for entering clinical information, adding information to the database, and setting reminders. The system's conceptual model was then depicted using a visual paradigm to define functional, structural, and behavioral models among data elements by generating UML diagrams (class, activity, use-case, and sequence). The application was then created using Eclipse (V.22.2.1) and the Android Development Tools.

Furthermore, SQLite was used to develop the database, which is a popular choice because it is used by a variety of browsers, operating systems, and embedded systems (such as cell phones) nowadays. Many programming languages have SQLite bindings.

C- Evaluation and Revision

A usability study on ASKLO was conducted with 12 participants to assess the application's usefulness. Six patients with knee osteoarthritis and six patients with lumbar osteoarthritis took part in the study. The selection criteria included being available, owning an Android smartphone, knowing how to use cell phone apps, and having an Internet connection. The usability of the system was assessed in this phase using a questionnaire for user interaction satisfaction (QUIS).

QUIS is a tool for determining a computer user's subjective satisfaction with a human-computer interface. It was created at the University of Maryland, at College Park's human-computer interaction laboratory (HCIL). A demographic questionnaire, a measure of overall system satisfaction, and a measure of specific interface factors, including screen visibility, terminology, system information, learning variables, and system capabilities, were all included.

On a 9-point Likert scale, each domain assessed users' overall satisfaction with that aspect of the interface and the variables that formed that aspect. The questionnaire was designed to be customized for each interface analysis, with just the parts relevant to the user included. The evaluation of the data was conducted in SPSS-22 using descriptive statistics.

It's worth noting that the impact of the application on patients' self-management was not evaluated in this study.

Results

At first, the literature review yielded 48 features and their associated elements, which were then implemented into the application. During the CVR and CVI processes, two components related to demographic data were eliminated. After using the Delphi technique, researchers added a reminder for medicine and examination, as well as e-mail communication with a doctor, to the capabilities section, and medication was withdrawn from the patient education area. Table 1 shows the final results of Delphi as content of ASKLO.

After that, a prototype of the application was created. As seen in Figure 1, the ASKLO app's home screen contents are as follows:

1.The medical records module included a diary of self-reported information about treatment and self-management as well as personal medical data such as laboratory test results, radiology reports, family history, surgery history, allergies, and social history.

2.The educational information module provided information about diseases and treatments.

3.Daily weight, exercise, nutrition, and symptoms were all tracked in the record activities module.

4.There were three reminders in the module of reminders: exercise, diet, and doctor's visits.

5.There were three themes in the disease management module: nutrition, physical activity, and stress management.

6. The report's module covered laboratory tests, medical imaging, disease signs, patient conditions, therapies employed, vitamin consumption, therapeutic history, weight changes, and physical activities.

Table1: Results of the survey regarding content determination of ASKLO

Data elements				Mean	percentage
1	Demographic information	Full name		3.93	78.6
		Age		4.47	94.8
		Gender		4.77	95.4
		Occupation		4.5	90
		Weight		4.87	97.4
		Height		4.9	98
		Geographical area		4.29	85.8
2	Life style	Physical activity		4.67	93.4
		Nutrition		4.48	89.6
		Smoking		4.16	83.2
		Mental stress		4.48	89.6
3	Clinical information	Symptoms	Knee pain	4.9	98
			Back pain	4.93	98.6
			Reduced functioning	4.83	96.6
			Morning fatigue less than 30 seconds	4.58	91.6
			The rubbing sound with joint and crypto movements	4.51	90.2
			Swelling and loss of joint flexibility	4.67	93.4
		Other underlying diseases	Rheumatoid arthritis	4.67	93.4
			Other rheumatic diseases	4.45	89
4	Laboratory findings	Calcium		4.32	86.4
		Vitamin D		4.5	90
		CBC		4.22	84.4
		Ferritin		3.77	75.4
		Phosphor		3.77	75.4
	Radiology findings	Radiography of affected joints		4.33	86.6

Data elements					Mean	percentage
5	educating the patient on	Types of disease			4.58	91.6
		Different symptoms of the disease			4.51	90.2
		Medications			0.7	1.4
		Facilitating factors			4.83	96.6
		Types of diagnostic methods of the disease			3.9	78
6	Lifestyle management	Nutrition	Patient's knowledge on proper nutrition		4.47	94.8
			Providing information about its ingredients		4.54	90.8
		Exercising to reduce pain such as aerobics, yoga, and ...			4.67	93.4
		Traditional pain treatments	Massage therapy		4.32	86.4
			Hot water bags		4.32	86.4
			Herbal remedies		4.32	86.4
		Stress management			4.74	94.8
7	Capabilities of the application	Alerts and reminder	Exercise		4.83	96.6
			Nutrition		4.83	96.6
			Medications		0.7	1.4
			Examinations		0	0
			Doctor's visit		4.93	98.6
		BMI calculation			4.93	98.6
		Contacting a doctor by Email, ...			0.7	1.4
		Recording the activity's level			4.83	96.6

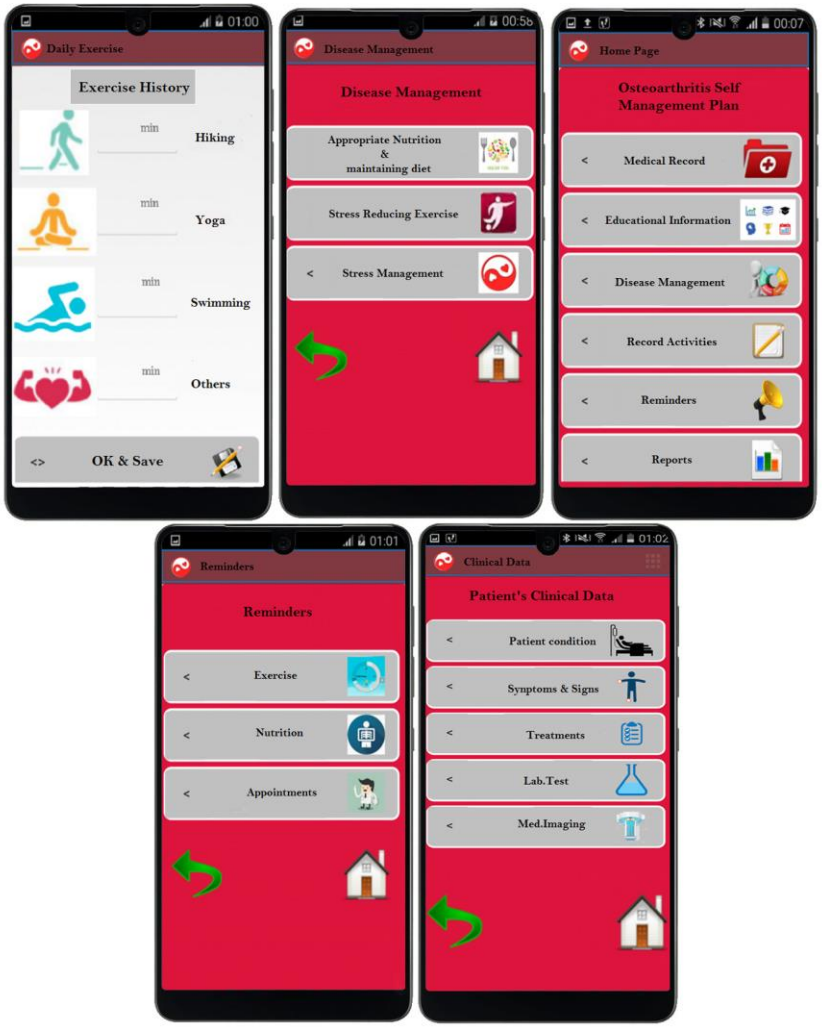

Figure 1: ASKLO screenshots

Afterward, the application was installed on the users' phones, and its Android compatibility was confirmed. Patients were then asked to log into the application and enter clinical information such as medical history, laboratory test results, radiology reports, doctor's appointments, and daily activities including food consumption and physical activities. Then, they used a QUIS to evaluate the application's functionality, ease of access, and use of various sections.

Following the evaluation, the application was upgraded to include user feedback and make the necessary modifications. Some of the suggestions were to add daily notes and a way for patients with osteoarthritis to share their experiences; upload radiographic images; modify the font of the words; the background and color of pages; and add more educational information about sports activities and nutritional diets to reduce pain in osteoarthritis. Finally, as shown in Table 2, participants indicated that ASKLO's usability was at an anticipated level (7.56 out of a possible 9).

Table2: Results of the usability evaluation regarding ASKLO

Row	Title and response	0	1	2	3	4	5	6		7		8		9		Mean	SD
		No	No	No	No	No	No	No	Percentage	No	Percentage	No	Percentage	No	Percentage		
Overall system satisfaction																	
1	The general function of the program	-	-	-	-	-	-	1	8.33	8	66.66	3	25	0	0	7.16	0.6
2	Ease of using the program	-	-	-	-	-	-	4	33.33	4	33.33	3	25	1	8.33	7.08	1.04
3	How the user	-	-	-	-	-	-	0	0	4	33.33	5	41.66	3	25	7.91	0.77
4	The general design of the	-	-	-	-	-	-	1	8.33	5	41.66	6	50	0	0	7.41	0.68
5	Continuous work with the program	-	-	-	-	-	-	0	0	6	50	6	50	0	0	7.5	0.52
6	Program setting capabilities	-	-	-	-	-	-	3	25	4	33.33	4	33.33	1	8.33	7.25	1
Screen visibility																	
7	The readability of the letters on the screen	-	-	-	-	-	-	2	16.66	5	41.66	2	16.66	3	25	7.5	1.12
8	easily perform The tasks using specific phrases in the	-	-	-	-	-	-	1	8.33	7	58.33	3	25	1	8.33	7.33	0.80
9	Organization of information	-	-	-	-	-	-	3	25	4	33.33	5	41.66	0	0	7.16	0.87
10	The sequence of screen pages	-	-	-	-	-	-	3	25	7	58.33	2	16.66	0	0	6.91	0.70
Terminology and system information																	

11	Use of terms in the program	-	-	-	-	-	-	3	25	6	50	1	8.33	2	16.66	7.16	1.1
12	A set of terms related to work in the program	-	-	-	-	-	-	1	8.33	7	58.33	2	16.66	2	16.66	7.41	0.93
13	Location of messages on the screen	-	-	-	-	-	-	2	16.66	7	58.33	1	8.33	1	8.33	6.5	0.93
14	Message to record essential data	-	-	-	-	-	-	3	25	6	50	2	16.66	2	16.66	7.83	0.75
15	Program messages about completing tasks	-	-	-	-	-	-	5	41.66	4	33.33	2	16.66	2	16.66	7.66	
16	Error messages in the program	-	-	-	-	-	-	5	41.66	7	58.33	0	0	0	0	6.58	0.52
Learning factors																	
17	Learning to work with the program	-	-	-	-	-	-	5	41.66	3	25	2	16.66	2	16.66	7.08	1.01
18	Finding program properties through trial and error	-	-	-	-	-	-	6	50	2	16.66	1	8.33	1	8.33	5.58	0.89
19	Memorizing names and using program capabilities	-	-	-	-	-	-	2	16.66	6	50	3	25	3	25	8.75	0.67
20	Performing tasks quickly and easily	-	-	-	-	-	-	2	16.66	6	50	3	25	3	25	8.75	0.94
21	Instructional messages on the screen	-	-	-	-	-	-	5	41.66	5	41.66	2	16.66	2	16.66	8.25	0.78
22	Supplementary educational references	-	-	-	-	-	-	4	33.33	4	33.33	2	16.66	2	16.66	7.16	1.03
System capability																	
23	Program speed	-	-	-	-	-	-	5	41.66	3	25	3	25	2	16.66	7.75	1.02
24	Program availability	-	-	-	-	-	-	4	33.33	6	50	2	16.66	1	8.33	7.58	0.75
25	Multiple	-	-	-	-	-	-	3	25	3	25	6	50	3	25	9.5	0.9
26	Correcting the user's errors when entering data	-	-	-	-	-	-	2	16.66	4	33.33	5	41.66	3	25	8.91	1.04
27	Suitable design for different users	-	-	-	-	-	-	3	25	6	50	3	25	3	16.66	8.5	0.77
The total sum of mean and standard deviation																7.56	0.85

Discussion

Lifestyle adjustments have become increasingly important for enhancing the quality of life and managing chronic disease symptoms. It's critical to keep track of lifestyle and clinical data, as well as a variety of data variables like age, sex, weight, and medical history as key causes of osteoarthritis (19). According to several studies, the use of cell phone applications or other electronic interventions has a significant impact on improving health status monitoring, positive lifestyle changes, and patient awareness and self-confidence (20–25). Below are some examples:

In their study, **Dahlberg et al.** explained that "joint academy, a web-based platform for osteoarthritis therapy, has the potential to successfully deliver individualized online treatment to many patients with osteoarthritis who currently lack access to treatment" (26).

Jones et al. found that health technologies provide continuous, real-time feedback to patients with osteoarthritis on their overall level of activity. It is for a more proactive, personalized approach to treatment that may help modify behavior and assist with self-management through treatment support in the form of motivational messaging (27).

Hawamdeh et al. developed a decision support system (DSS) to anticipate physician-recommended rehabilitation programs for patients with knee osteoarthritis. This method correctly predicted the treatment recommended by the physician in 87 percent of cases. This DSS is primarily based on the demographic and clinical characteristics of the patients (28).

In their study, **Rao et al.** revealed the potential for tele-rehabilitation to increase access to care and lower costs for patients with osteoarthritis living in rural areas (29)

Kao et al. assessed the impact of a self-management program on the quality of life for elderly people suffering from knee osteoarthritis. Finally, they discovered that "the arthritis's self-management software enhanced the participants' psychological outcomes; but, it had no meaningful influence on their self-reported disability level (30).

The ASKLO is a technology-based tool designed to assist people with knee and lumbar osteoarthritis in making lifestyle changes.

A spate of smartphone applications have been developed to help with disease self-management. All of them are based on three axes: the user, the application's features, and the behavior change. Because users' cultural and social contexts are just as important as scientific and technical issues (15), involving patients as co-designers in an application's creation with physicians, academics, and application designers is more effective in providing high-quality and individualized care to each patient (31-37).

As **Tomita** et al. in their study said, "An interdisciplinary team and a patient-centered design were vital to achieving a comprehensive mHealth approach directed to improving therapy management, patient empowerment, and patient-provider interactions" (38).

Aside from that, **De Sola et al**. observed that better collaboration between patients and physicians is needed for high-quality applications, and academic developers' engagement is particularly helpful in studying and analyzing mobile applications in rheumatology using the mobile application rating scale (MARS) (39).

Also, **Petersen et al.** in their study enlightened, "Users in our study considered it crucial that healthcare professionals introduce the app because it created a trust. Some users were afraid of using self-selected apps because they might contain out-of-date or incorrect information" (35).

On the other hand, patients' awareness of

their health and pain management is particularly effective in improving their lifestyle and preventing further disease complications and exacerbation (26, 27). Moreover, if applications are developed by academics, users will assume they are getting accurate and evidence-based information (2). According to a study by **Hsiao et al.**, patients wanted to know who acknowledged the information they were given. As a result, application developers' qualifications must be scrutinized (15).

In the present study, a team of academic specialists in rheumatology, health information management, medical informatics, and also patients as end-users collaborated to create the ASKLO.

Regarding the application's features, patient communication is one of the most important components of its design because it motivates patients to use it (40). According to **Schuuring et al.**'s study, "a successful program to enhance one's behaviors in controlling heart failure entails a multidisciplinary approach to design and offering feedback regarding a patient's daily record, which can be done through the Internet" (38).

In addition, patients want to talk about their online experiences, and it is proposed that they be allowed to communicate with the community, peers, and specialists (14). Patients are also urged to prioritize self-care by being able to track their daily activities (41). Reminders of daily training programs are extremely helpful in self-management, particularly when cell phone apps empower older individuals (14, 42).

As a result, automated message systems, the ability to manage and monitor crucial indications, and the ability to send prescription and appointment reminders have all become more common. Although the ASKLO is a technology-based tool designed to assist people with knee and lumbar osteoarthritis in making lifestyle changes, it is not a web-based program.

Conclusion

This software is intended to deliver reliable information to patients as a tool to help them manage their sickness. Furthermore, during outbreaks, such an app can provide continuous services to limit the exposure of healthcare staff, social ties, and the necessity for patients to leave their homes and be exposed to the infected environment. In a trial phase, the app's usability and viability are being assessed. Based on the results of the pilot usability research, more complex functionality will be added to the app.

Future research will look into how ASKLO helps people with osteoarthritis manage their pain and participate in physical activities. Despite its advantages, this app has some limitations, such as being suited to the Android operating system, the Persian language, and the fact that it is not a web-based application. As the number of individuals who use this app grows, more feedback from patients and healthcare providers will be received, which will be used to improve it.

Disclairmer statements

- **Author contributions:** L.Sh. supervised the project, the main conceptual idea, and the proof outline. M.B worked out almost all of the technical details and performed the numerical calculations. M.K. verified the analytical method, interpreted the results, and wrote the manuscript.
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References

1. Agarwal P, Mukerji G, Desveaux L, Ivers NM, Bhattacharyya O, Hensel JM, et al. Mobile App for

Improved Self-Management of Type 2 Diabetes: Multicenter Pragmatic Randomized Controlled Trial. JMIR mHealth and uHealth. 2019;7(1): e10321.
2. Rasche P, Gulliver A, Portenhauser AA, Terhorst Y, Schultchen D, Sander LB, et al. Mobile Apps for Older Adults: Systematic Search and Evaluation Within Online Stores. JMIR Aging. 2021;4(1).
3. Lipson-Smith R, White F, White A, Serong L, Cooper G, Price-Bell G, et al. Co-Design of a Consultation Audio-Recording Mobile App for People With Cancer: The SecondEars App. JMIR formative research. 2019;3(1):e11111.
4. Zhang C, Song W, Yu H, Ye Q, Zhou J, Wu H. Using Information Technology to Manage the COVID-19 Pandemic: Development of a Technical Framework Based on Practical Experience in China. JMIR Medical Informatics. 2020 Jun 8;8(6):e19515.
5. Grange ES, Neil EJ, Stoffel M, Singh AP, Tseng E, Resco-Summers K, et al. Responding to COVID-19: The UW Medicine Information Technology Services Experience. Applied Clinical Informatics. 2020;11(2):265-75.
6. Carpenter KM, Stoner SA, Mundt JM, Stoelb B. An online self-help CBT intervention for chronic lower back pain. The Clinical journal of pain. 2012;28(1):14-22.
7. Deldar K, Johansson M, Amiri D, Huckins J, Kolotylo-Kulkarni M, Cruz-Martínez RR, et al. Supporting Self-Management of Cardiovascular Diseases Through Remote Monitoring Technologies: Metaethnography Review of Frameworks, Models, and Theories Used in Research and Development. Journal of Medical Internet Research. 2020;22(5):e161578.
8. Rana A, Lundborg C, Wahlin Å, Ahmed S, Kabir ZN. The impact of health education in managing self-reported arthritis-related illness among elderly persons in rural Bangladesh. Health education research. 2008;23(1):94-105.
9. Østerås N, Moe RH, Fernandes L. Telephone-based patient self-management program might be effective in reducing osteoarthritis-related pain. Journal of physiotherapy. 2011;2(57):125.
10. Goode AP, Carey TS, Jordan JM. Low back pain and lumbar spine osteoarthritis: how are they related? Current rheumatology reports. 2013;15(2):305.
11. Frough B, Mianesaz E, Ahadi T, Raissi Gh, H. F, A M. Single injection of platelet-rich plasma in knee osteoarthritis: a pilot study. Razi Journal of Medical Sciences. 2015;22(133. Razi Journal of Medical Sciences. 2015;22(133):27-34.
12. Malekzadeh J, Fararooei M. Preventing of osteoporosis: Applying the health belief model. Advances in Nursing & Midwifery. 2015;24(87): 15-22.
13. Anekwe TD, Rahkovsky I. Self-Management: A Comprehensive Approach to Management of Chronic Conditions. Am J Public Health. 2018;108(Suppl 6):S430-6.
14. Fletcher S, Kulnik ST, Demain S, Jones F. The problem with self-management: Problematising self-management and power using a Foucauldian lens in the context of stroke care and rehabilitation. PLoS ONE. 2019;14(6).
15. Hsiao FH, Drusany Starič K, Lim JH, Hou IC, Lan MF, Shen SH, et al. The Development of a Mobile Health App for Breast Cancer Self-Management Support in Taiwan: Design Thinking Approach. JMIR mHealth and uHealth. 2020;8(4). e15780.
16. Berg RL. Educating the consumer: patient education and preventive medicine. Bulletin of the New York Academy of Medicine. 1981;57(1):80.
17. Rodrigues IB, Adachi JD, Beattie KA, MacDermid JC. Development and validation of a new tool to measure the facilitators, barriers and preferences to exercise in people with osteoporosis. BMC Musculoskeletal Disorders. 2017; 18(1):540.
18. Almanasreh E, Moles R, TF. C. Evaluation of methods used for estimating content validity. Research in Social and Administrative Pharmacy. 2019;15(2):214-21.
19. Tian W, Lv Y, Liu Y, Xiao B, Han X. The high prevalence of symptomatic degenerative lumbar osteoarthritis in Chinese adults: a population-based study. Spine (Phila Pa 1976). 2014;39(16):1301-10.
20. Ong SW, Jassal SV, Miller JA, Porter EC, Cafazzo JA, Seto E, et al. Integrating a Smartphone-Based Self-Management System into Usual Care of Advanced CKD. Clinical journal of the American Society of Nephrology : CJASN. 2016;11(6):1054-62.
21. Nes AA, van Dulmen S, Eide E, Finset A, Kristjánsdóttir OB, Steen IS, et al. The development and feasibility of a web-based intervention with diaries and situational feedback via smartphone to support self-management in patients with diabetes type 2. Diabetes research and clinical practice. 2012;97(3):385-93.
22. Lee MK, Park H-A, Yun YH, Chang YJ. Development and formative evaluation of a web-based self-management exercise and diet intervention program with tailored motivation and action planning for cancer survivors. JMIR Research Protocols. 2013;2(1):e11-e.
23. Yu CH, Parsons JA, Mamdani M, Lebovic G, Hall S, Newton D, et al. A web-based intervention to support self-management of patients with type 2 diabetes mellitus: effect on self-efficacy, self-care and diabetes distress. BMC Medical Informatics and Decision Making. 2014;14(1): 117.

24. Cafazzo JA, Casselman M, Hamming N, Katzman DK, Palmert MR. Design of an mHealth app for the self-management of adolescent type 1 diabetes: a pilot study. Journal of Medical Internet Research. 2012;14(3):e70.
25. Tomita MR, Tsai B-M, Fisher NM, Kumar NA, Wilding G, Stanton K, et al. Effects of multidisciplinary Internet-based program on management of heart failure. Journal of multidisciplinary healthcare. 2009;2:13-21
26. Dahlberg LE, Grahn D, Dahlberg JE, Thorstensson CA. A Web-Based Platform for Patients With Osteoarthritis of the Hip and Knee: A Pilot Study. JMIR Research Protocols. 2016;5(2):e115.
27. Jones D, Skrepnik N, Toselli RM, Leroy B. Incorporating Novel Mobile Health Technologies Into Management of Knee Osteoarthritis in Patients Treated With Intra-Articular Hyaluronic Acid: Rationale and Protocol of a Randomized Controlled Trial. JMIR Research Protocols. 2016;5(3):e164.
28. Hawamdeh ZM, Alshraideh MA, Al-Ajlouni JM, Salah IK, Holm MB, Otom AH. Development of a decision support system to predict physicians' rehabilitation protocols for patients with knee osteoarthritis. Int J Rehabil Res. 2012;35(3): 214-9.
29. Rao K, Iyer C, D A. Can Telerehabilitation Add a New Dimension in the Treatment of Osteoarthritis Knee?. J Pain Relief 2012;2:113.
30. Kao MJ, Wu MP, Tsai MW, Chang WW, Wu SF. The effectiveness of a self-management program on quality of life for knee osteoarthritis (OA) patients. Archives of gerontology and geriatrics. 2012; 54(2):317-24.
31. Gaynor M, Schneider D, Seltzer M, Crannage E, Barron ML, Waterman J, et al. A user-centered, learning asthma smartphone application for patients and providers. Learning Health Systems. 2020;4(3).
32. Couture B, Lilley E, Chang F, DeBord Smith A, Cleveland J, Ergai A, et al. Applying User-Centered Design Methods to the Development of an mHealth Application for Use in the Hospital Setting by Patients and Care Partners. Applied Clinical Informatics. 2018;9(2):302-12.
33. Dewar A, Grainger R, Dicianno BE, Henderson G, Parmanto B. Design of Mobile Health Tools to Promote Goal Achievement in Self-Management Tasks. JMIR mHealth and uHealth. 2017;5(7).
34. Matthias G, Meinert E, Wicks P, Morita PP, Yeung MS, Ferrone M, et al. A Patient-Centered Mobile Health System That Supports Asthma Self-Management (breathe): Design, Development, and Utilization. JMIR mHealth and uHealth. 2019;7(1): e10956.
35. Petersen M, Hempler NF. Development and testing of a mobile application to support diabetes self-management for people with newly diagnosed type 2 diabetes: a design thinking case study. BMC Medical Informatics and Decision Making. 2017 Jun 26;17(1):91.
36. Righi R, Costa C, Oroojeni Mohammad Javad M, Klein D, Zhou L, DeAlmeida D, et al. Applying a User-Centered Approach to Building a Mobile Personal Health Record App: Development and Usability Study. JMIR mHealth and uHealth. 2019;7(7) :e13194.
37. Guo Y, Y C, Lane D, Liu L, Wang Y, Lip G. Mobile Health Technology for Atrial Fibrillation Management Integrating Decision Support, Education, and Patient Involvement: mAF App Trial. The American Journal of Medicine. 2017;130(12):1388-96.
38. Schuuring M, Treskes R, Gomis-Pastor M, Mirabet S, Roig E, Lopez L, et al. Interdisciplinary Mobile Health Model to Improve Clinical Care After Heart Transplantation: Implementation Strategy Study. JMIR Cardio. 2020;4(1).
39. de Sola H, Peters G, Salazar A, Knitza J, Tascilar K, Messner EM, et al. German Mobile Apps in Rheumatology: Review and Analysis Using the Mobile Application Rating Scale (MARS). JMIR mHealth and uHealth. 2019;7(8).
40. McCallum C, Rooksby J, Korpershoek YJG, Hermsen S, Schoonhoven L, Schuurmans MJ, et al. User-Centered Design of a Mobile Health Intervention to Enhance Exacerbation-Related Self-Management in Patients With Chronic Obstructive Pulmonary Disease (Copilot): Mixed Methods Study. Journal of Medical Internet Research. 2020;22(6): e15449..
41. Vardeh D, Edwards R, Jamison R, Eccleston C. There's an app for that: Mobile technology is a new advantage in managing chronic pain. Pain. 2013;21:1-7.
42. Portelli P, Eldred C. A quality review of smartphone applications for the management of pain. British journal of pain. 2016;10(3):135-40.
43. Ford D, Harvey JB, McElligott J, King K, Simpson KN, Valenta S, et al. Leveraging Health System Telehealth and Informatics Infrastructure to Create a Continuum of Services for COVID-19 Screening, Testing, and Treatment Accelerating the global response against the exponentially growing COVID-19 outbreak through decent data sharing. J Am Med Inform Assoc. . 2020; 9;27(12):1871-1877.
44. Garvin L, Yen PY, Lee Y, Wang P, Irfan Khan A, Gill A, et al. mHealth Tools for the Self-Management of Patients With Multimorbidity in Primary Care Settings: Pilot Study to Explore User Experience. JMIR mHealth and uHealth. 2018;6(8).