






Mobile health applications for osteoporosis support available on the market: A systematic review

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ABSTRACT

Introduction: The use of mobile applications (apps) become widespread and Provide many benefits especially in healthcare. According to the World Health Organization, osteoporosis is one of the most common diseases of elderly in the world. Like other chronic conditions, disease self-management can prove fruitful. Using a mobile application for Osteoporosis can improve patient care and self-management by encouraging patients to take a more active role in their health.

Material and Methods: This study presents a systematic review of mHealth applications, available on Google Play Store, Bazaar market (as a local market) and also Apple App Store, for both the English and Persian speakers. The assessment criteria, including content, visual aids, reminders, health warnings, social and design of selected apps, were tested during July 2019.

Results: Reviewing the 19 included applications showed that the most and least focus of apps content was on exercise with 84% repetition and the osteoporosis fracture that no program addressed this issue separately. Findings on reminders, health warnings, and visual aids were not very encouraging (available in 11% apps). Reminders were more common in English-speaking apps than Persian-speaking ones, and Visual aids, one of the benefits of mobile apps over paper logbooks, were provided only in 2 apps. The opportunity to share data in social networks was available in 26% of apps, and in the design section, most of the apps have no significant flaws, but 74% of cases did not provide any clear instructions required for the elderly.

Conclusion: The review shows that there are rather few products on offer and the ones that are available display low quality, poor performance, and evidence-based information is also insufficiently used. Further efforts are required to collect data that will support the design of validated evidence-based educational functions for mHealth apps.

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INTRODUCTION

The use of mobile applications (apps) has become widespread and has given many benefits. In this case, many would argue that professionals and customers have entered the era of mobile health (mHealth) in which mobile technologies play a much larger role in healthcare [1, 2]. The industry of these apps is

expanding rapidly [3]. The number of apps for two leading app stores, Google Play Store and Apple's App Store, are 2.57 and 1.84 million respectively, among which a lot are medical or healthcare apps [3-5]. M-health provided many functions and opportunities. They make a new way to promote disease prevention, facilitate the transition of care beyond the hospital setting to the home of patients, and also improve the

management of chronic diseases. In the same way, m-health can reduce costs, increase access to services, and improve patient care and self-management by encouraging patients to take a more active role in their health [6-11].

In particular, M-Health Apps will provide advantages for osteoporosis [12]. Osteoporosis is a serious condition and has been announced by the World Health Organization as the four main enemies of human health. It happens as a result of the aging process that bones are weakened in composition and structure [13, 14]. Due to the fact that populations around the world are rapidly aging, serious consideration is required, especially in Iran [15]. According to United Nations, the number of people over the age of 65 in the world will increase from 11% to 22% (more than 2 billion people) in 2050; in this report, Iran is the third country at the population aging rate after the Arab Emirates and Bahrain [16]. Osteoporosis would bring out many problems and poses a substantial economic burden to health systems, patients, and their families [17]. Despite the fact that osteoporosis is a preventable and manageable condition, the rate of appropriate investigation and management of patients with osteoporosis is very low and the majority of individuals who sustain fragility fractures, which is the most significant concern in osteoporosis, are not receiving adequate management [18]. The individual responsibility for health and self-management of chronic diseases is a concept with growing interest during the last decades and m-health can be useful for this purpose [19, 20]. Recent findings from Jakobsen et al. study suggest that m-health apps have the potential to support osteoporosis self-management and enabled women diagnosed with asymptomatic osteoporosis to feel confident [21].

However, many of the available mHealth apps are of low quality, even those that are highly rated [19-21]. These may have significant effects and can pose different types of risks to users [18]. For example, a recent study found that a mobile app claiming to provide diagnostic recommendations for suspected melanoma had very low sensitivity and was therefore likely to miss many melanomas [22]. The main aim of this contribution is to present a review of the current offer of mHealth devices for osteoporotic patients support for the Persian-speaking and English-speaking public. The reason for concentrating on this topic is that the review is a preparatory step towards the development and test of a mobile application to support osteoporotic patients with a fragility fracture in the context of a research project at Tehran University of medicine in Tehran (Iran). Moreover, testing the app in the Iranian context is considered as a first step towards an extension of the device also to other contexts. Based on this review, we are

particularly interested to answer the following questions: how many apps are there?; what kind?; which functions do they have?; and especially, given the relevance of self-management and education-oriented functionalities, how do these apps integrate these components?

MATERIAL AND METHODS

In our review, we searched the apps available for the Persian-speaking and English-speaking public, downloaded, and tested them. Apps were identified through a search in Google Play Store (GPS) and Bazaar market (BM as a local market) (for the Android mobile operating system) and Apple App Store (AAP) (for the IOS mobile operating system) during July 2019. We considered the first 60 entries on all stores for each of the following keywords: "Osteoporosis", "Osteoporotic Fracture" and "Fracture" by itself in both Persian and English.

We selected the apps using the following criteria:

Inclusion criteria

- Apps that have English/Persian-language user interfaces;
- App used for osteoporosis and osteoporotic fractures
- Apps designed to be used primarily by patients
- Apps designed (also) for pain relief or physiotherapy Exercises

Exclusion criteria

- Apps that have non-English or non-Persian user interface
- Apps designed to be used by doctors and/or other care professionals;
- Apps that are not primarily designed for osteoporosis self-management (e.g., recipe apps; advertising apps, such as Health saver, augmented reality apps such as osteoporosis AR);
- Apps which are not free for download (including those with free downloads for basic subscriptions, with additional fees for extra features);
- Apps provided by healthcare facilities requiring login;
- Duplicated apps.

The test

The apps were installed and used for a month. Finally,

the authors observed the apps' responses by focusing on both verbal and visual dimensions.

Assessment criteria

The reported design, content, and functions of the 19 selected apps were reviewed. Specifically, Apps were analyzed according to chronic disease management model [23, 24], that focuses on Patient We analyzed education and reminders besides some criteria extracted from related studies [25, 26], so we have considered the following:

Content: Materials and instruction provide patients with information about their condition and how it could be managed.

Reminders: What encourages patients to perform specific tasks related to the care of the condition?

Visual aids: functions aimed at providing visual feedback and display patient performance

Health warnings: evaluating the patient's condition and providing patients with messages and information about their condition.

Social: the function that supports the sharing of information and ideas with others in social networks

Design: is a multi-dimensional criterion and can be viewed from different perspectives. We considered the 3 dimensions based on Nielsen's 10 usability heuristics for user interface design, which were considered to be the most frequent defects in mobile apps:

Error prevention: a careful design which prevents a problem from occurring in the first place

Recognition rather than recall: the ability to minimize the memory load of users, such as remembering patient choices, and providing visible and easily retrievable instructions on how to use the system.

Aesthetic and minimalist design: avoid providing irrelevant or rarely required information [27, 28].

RESULTS

In the first step, 49 GPS apps, 29 BM apps, and 43 AAS apps were included, of which only 29 were eligible. Of the 92 rejected apps, about 21% do not have English nor Persian-language user interface (89% for Android category and 11% for IOS category), 20% are paid app (89% for Android category 11% for IOS category) 4% are apps need login (25% for Android category and 75% for IOS category), 34% are not app designed for the task of osteoporosis self-management (29% for Android category 71% for IOS category) and 21% not designed for patients (42% for Android category 58% for IOS category). The total number of eligible apps is 12 for the GPS, 14 for the BM, and 3 for the AAS of which, 3 are duplicate apps (GPS and BM have 2, and GPS and AAS have 1 in common) and were thus left out. Besides, due to the similar design, identical reference, and overlapping content in 10 BM apps, (2 with reference to www.beytoote.com include "Prevention of Osteoporosis" and "Fight Osteoporosis" and 8 with reference to www.hidoctor.com include "Bone Health (3 version)", "Bone diseases (2 version)", "Bone", "Bone Secret" and "Bone Care") the first results were used, and the rest were omitted. Overall, the final selection is 19 apps. Fig 1 shows the details of this selections.

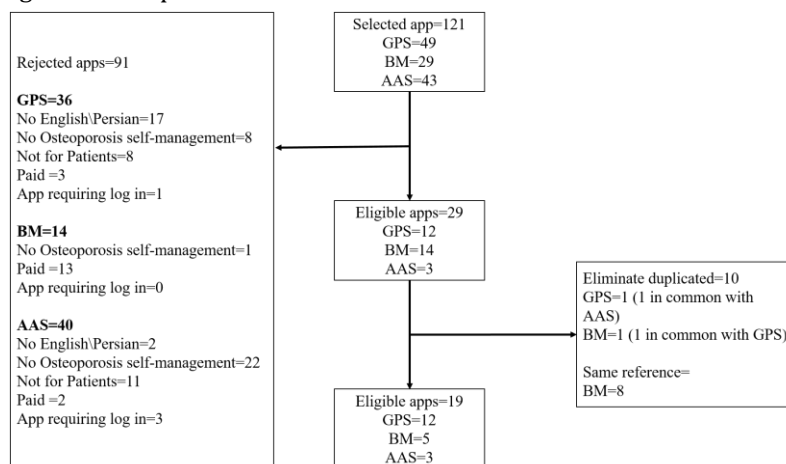


Fig 1: App selection process and result

Table 1 shows the characteristics and functionalities of the tested apps. Technical information is described in the first three columns: for each app, the table shows whether it is available on the GPS, BM, AAS,

and sometimes on both; the version number; the average rating. The following six columns are for data entry or content (Diet, Exercise, Diagnosis, Medication, and Fracture), followed by eight other features described above.

Table 1: Data abstraction of reviewed apps

Application	Store	Version	Average rating	Content						Reminders	Visual aids	Health warning	Social	Error prevention	Recognition rather than recall	Aesthetic and minimalist design
				Diet	Exercise	Diagnosis	Medication	Fractures	Export/data sharing							
Fight Osteoporosis	GPS, BM	3	-	Y	Y	N	N	N	Y	N	N	N	N	Y	N	Y
Osteoporosis cure naturally	GPS	2	3.8	Y	Y	N	Y	N	Y	N	N	N	N	Y	Y	N
Osteoporosis disease	GPS	1	3.0	N	N	Y	Y	Y	N	N	N	N	N	Y	N	N
Osteoporosis info	GPS	1.	5	Y	Y	Y	Y	Y	N	N	N	N	N	Y	Y	Y
Osteoporosis cure	GPS	1	-	Y	Y	Y	Y	Y	N	N	N	N	N	Y	N	N
My arthritis	GPS	2.30.46	-	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N	Y	Y
Osteoporosis	GPS	1.0	5	Y	Y	Y	Y	N	N	N	N	N	N	Y	N	Y
All bone diseases	GPS	1.78	4.0	Y	Y	Y	N	N	N	N	N	N	N	Y	N	N
The spine app	GPS	1.1	3.7	N	Y	N	N	N	Y	N	N	N	N	Y	N	Y
Fracture	GPS	1.1	3.7	N	N	Y	N	Y	N	N	N	N	N	Y	N	Y
Lower back pain Exercise	GPS	2.0.1	4.5	N	Y	N	N	N	N	N	N	N	N	Y	N	Y
Osteoporosis	BM	1.1.7	4.3	Y	Y	N	N	N	Y	N	N	N	N	Y	N	Y
Prevention of Osteoporosis	BM	1.0	5.0	Y	Y	N	N	N	Y	N	N	N	N	Y	N	Y
Bone Health	BM	1	4.8	Y	Y	Y	N	N	Y	N	N	N	N	Y	N	N
Osteoporosis and consultation	BM	1	4.7	Y	Y	Y	N	Y	Y	N	N	N	Y	Y	N	Y
Healthy Bone	BM	3.1	-	Y	Y	Y	N	N	N	N	N	N	N	Y	N	N
Osteoporosis by Azo medical	AAS	2.1	N	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y	N	Y
My Osteoporosis Manager	AAS	10.0.0	N	N	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
My Osteoteam	AAS, GPS	11.7.0	1	Y	Y	Y	Y	Y	N	N	N	N	Y	N	Y	N

In the area of reminder, warning, and visual aids, only 2 apps (My arthritis from GPS and My Osteoporosis Manager from AAS) were able to meet study criteria such as sending prompt messages, evaluating user status, or providing any graphs, diagrams, tables or statistics as a visual feedback, and 89% were

incapable. In the design part, 26% of apps have errors such as low speed or ineffective buttons. Table 2 summarizes the results of this study.

Table 2: Results for assessment criteria in the reviewed apps

Features and functions	Yes	No	%
Diet	14	5	74
Exercise	16	3	84
Diagnosis	13	6	68
Medication	9	10	47
Fractures	8	11	42
Data sharing	9	10	47
Reminder	2	17	11
Visual aids	2	17	11
Health warnings	2	17	11
Social	5	14	26
Error prevention	14	5	74
Recognition rather than recall	5	14	26
Aesthetic and minimalist design	13	7	68

DISCUSSION

Self-management can help to manage the increasing burden of chronic diseases [29]. Interventions to support patients' self-management, were most strongly associated with improvements in patient process outcomes [30]. In this study, we consider to review the apps available in the market, developed to support the self-management of Osteoporosis, by considering some required aspects according to chronic disease management model along with features stated by Hoyt that were explained before. Many reviews have already underlined the lack of educational functions in the majority of m-health apps [18-21, 25, 31]. In the same vein, these results are also confirmed by our review. However, patient information is a key component of effective self-management in relation to osteoporosis and fracture preventions but information given at one point maybe too much to take in and an study showed that osteoporosis consultations contain too much of focus on pharmaceutical intervention than non-pharmaceutical one like diet and exercise which exactly opposite in terms of applications content in our review that The most focus of apps content was on exercise with 84% repetition which was predictable given that "Osteoporosis exercise" is the preferred term in the GPS [32]. So may be these two could cover each other gaps. In evaluating the content section of the applications, also it was found that the least amount of attention was paid to the osteoporosis fracture section, and no program addressed this issue separately despite the fact that osteoporosis fracture is the most important complication of osteoporosis in the elderlies [33]. Findings on Reminders, health warnings, and visual aids were not very encouraging. Patient reminders are important in chronic diseases [24, 34]. Studies have shown that systems with computerized recall and reminders interventions have benefit on patient level outcome [24, 35]. Moreover, for one thing, maintaining medical adherence in older adults with

chronic diseases ensures that treatment is effective and, because of forgetfulness, reminders are needed [36]. The result of our study also showed that reminders in English-speaking apps are more common than Persian-speaking ones, which was the same with findings of Wu and et.al that concluded personal feedback and reminders were more popular in US apps than the Chinese ones [37]. Seeing images, graphs and generally visual aids presentation can improve the ease with which the users and the product interact and therefore the usability of that and in the study of Raybould et.al participant with osteoporosis mentioned that they asked for diagram and visual images [32, 38]. By the way, they are one of the advantages that mobile apps offer to patients upgrading from paper logbook to an electronic system, but in this study, only 2 apps provide this feature appropriately [39]. Similarly, data sharing, which is a good way to give feedback and facilitate interaction among patients, clinicians, researchers, and vendors, was provided in 5 apps. This finding is consistent with that of Kim (2018), who reviewed apps for drug-drug interaction check, and only 5 of the 23 reviewed apps provided this function [36]. Again, the results of evaluating the design part, which took more time particularly in the field of error prevention, indicated that most of the apps had no serious errors, but 74% of cases did not provide clear instructions that were necessary for the elderly. A possible explanation for this might be the lack of intelligence and the fact that most systems are one-dimensional in the delivery of information [40]. Also the fact that apps today frequently use active data entry like surveys instead of passive one such as smartphone sensors, GPS or call/text log [41]. Nevertheless, in this research, the presence of instructions or the probability of recalling the last studied page also distinguished between that app and others. Finally, the most critical aspect of aesthetics was the irrelevant details found in 7 apps (32%), and as stated earlier, most of the apps available, particularly in BM, have the same websites with a low information value as the reference. These results also support the work of Alessa et al. who found that the most of the existing apps are weak in terms of information resources. They have studied self-management applications in hypertension and have shown that few applications can perform well [42]. Our study also confirmed the result of Wisniewski et.al study that stated there is no correlations between star rating of an app and function of it [41].

CONCLUSION

This study reviewed 19 apps developed to support the self-management of Osteoporosis. Management of chronic disease requires that patients take a more active role in the day-to-day decisions about the

management of their illness. Our study shows that most of the apps have low quality, poor performance, and evidence-based information is also insufficiently used. A possible explanation for these results may be: 1- the lack of clean and acceptable standards for the development of apps [18]; 2- the lack of analysis tools (which according to the study by Erfani et.al. in 80% of cases the developers are also a tester) [43]; and 3- the fact that everybody can develop medical apps of the content don't have strong references that can bring out many risks [18]. A limitation of this study is that the review was conducted without considering paid apps, which may benefit, from a higher level of free apps. But in reality, cost is the primary criterion for the choice of the app. Moreover, the importance of public access to health information and the fact that 80% of disease-related deaths are prevalent in low-income countries [44], indicate the need for free access to m-health applications. Further efforts are required to collect data that will support the design of validated evidence-based educational functions for mHealth apps.

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AUTHOR'S CONTRIBUTION

(I) Conception and design: Reza Safdari, Foziyeh Tahmasbi, (II) Administrative support: Reza Safdari, (III) Collection and assembly of data: All Authors, (IV) Data analysis and interpretation: All authors, (V) Manuscript writing: All authors, (VI) Final approval of manuscript: All authors.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest regarding the publication of this study.

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No financial interests related to the material of this manuscript have been declared.

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