Surgical Patients Follow-Up by Smartphone-Based Applications: A Systematic Literature Review

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Abstract. Background: Telemedicine technology with the development of mobile applications (apps) has provided a new approach for the follow-up of patients. Objectives: This study aims to carry out an overview of the studies related to the use of mobile apps in the follow-up of surgical patients. Methods: In this study, an electronic search of four databases included PubMed, Scopus, Embase, and web of science was carried out. It included studies in the English language from the beginning of 2009 to June 2019. Results: Twenty-three articles were selected for the final analysis, that all of them were published from 2015 onwards. In most studies, fourteen to thirty-days follow-up period for different outpatient and inpatient surgeries was planned. Apps' components in the studies mostly include indexes for evaluation of recovery quality, pain level, and the surgical site infection. The most important achievement of studies included feasibility, early detection of complications, reducing unscheduled in-person visits, patients' self-efficiency, and satisfaction. Conclusions: Our review showed that mHealth-based interventions have potential that may support better management of post-discharge systematic follow-up of surgery patients.

Keywords. telemedicine, mHealth, smartphone, mobile application, follow-up, surgery

1. Introduction

At the moment, there is lack of a standard procedure for postoperative follow-up, so limited information is available regarding postoperative in-home recovery. This problem is more important for day surgery patients, because they are postoperatively monitored for a few hours before discharge [1]. It leads to a lack of feedback and information regarding normality and relevant expectations during the recovery period. Thus, many

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patients or caregivers feeling insecure and worried after discharge [2]. Moreover, unexpected visits or unnecessary readmissions may also happen at this time [3].

There are several options for postoperative follow-up [4] (e.g., telephone call, text messaging, or emails). Recently, telemedicine with the development of mobile technology, smartphones, and mobile applications (apps) is an effective approach to ensure the continuity of care also considered as a valid option to follow-up of patients [5]. Mobile health (mHealth) solutions with the development of smartphones as an easy to use, and low-cost technology, with mobile high-speed internet access, have provided transmission of data and real-time communication [6,7]. Since smartphones are ubiquitous and owned by a large majority of people, regardless of socioeconomic status and age groups, they are known as an ideal device for capturing patients-generated data and patient-reported outcomes [6]. In this regard, some studies confirm the effectiveness of mobile apps for the follow-up of discharged surgical patients [8-10].

The mHealth has proved promising in the management of chronic diseases [11]. Little attention is given to uses of platforms such as mobile apps in the follow-up of surgical patients, which is important for early detection of complications and providing appropriate intervention. The objective of this study was to carry out a systematic review of the articles related to using mobile apps in the follow-up of surgical patients.

This systematic review responds to the following research questions:

RQ 1. What is the characteristic of the studies?

RQ 2. Which components have been considered for the electronic follow-up programs?

RQ 3. What is the most important result or achievement of the studies?

2. Methods

This systematic review was reported according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [12].

2.1. Search strategy

An electronic search of four databases (PubMed, Scopus, Embase, and ISI web of science) was carried out. The search was limited to a 10-year period (between January 2009 and June 2019) and original article in English language. Table 1 shows steps for building the search query for the PubMed database. Equivalent searches also were conducted according to the instructions provided for the other three databases.

Table 1. PubMed search query

	SEARCH TERMS
1.	Monitor*[Title] OR Follow*[Title] OR Track[Title] OR Surveillance[Title] OR Care[Title] OR Management[Title] OR Intervention[Title] OR Control[Title] OR Visit[Title]
2.	Post*[Title] OR After*[Title] OR Home[Title] OR Remote[Title] OR Discharge[Title] OR Tele*[Title]
3.	Surger*[Title/Abstract] OR Surgical[Title/Abstract] OR Operative[Title/Abstract]
4.	Mobile[Title/Abstract] OR Smart*[Title/Abstract] OR “Smartphone*” [Title/Abstract] OR m*Health[Title/Abstract] OR mHealth[Title/Abstract]
5.	1 AND 2 AND 3 AND 4

2.2. Inclusion criteria

The search was restricted to the English language and published papers as an original article. Articles were included if they reported the results of mHealth in a follow-up manner in surgery patients only. Based on research aims, only the qualitative data elements from the articles were extracted.

2.3. Exclusion criteria

Because our aim was focused on reviewing mobile applications for follow-up of surgery patients in the post-discharge setting, thus, those reports regarding non-surgery patients, non-follow-up purposes, pre-operation monitor or even aim of the study was a feasibility and survey without the development or implementation of an app, were excluded. Also, wearable/sensor-based systems and self-care apps (without a remote monitoring platform on the care provider's side) were not entered. Papers based on telephone calls, text messaging or wound photography and submit by email without any mobile app not considered. In addition, review articles and research protocols were excluded.

2.4. Screening and article selection

Articles imported into EndNote reference management software. After the removal of duplicate records, papers screened at the title and abstract level by two researchers (T.B and M.E). Disagreements between investigators were resolved by consensus, or by consulting the third reviewer (Sh.RNK, M.GH). Records of potentially relevant articles were review for eligibility assessment.

3. Results

3.1. Included Studies

A systematic review of articles between 2009 and 2019 was conducted. Based on the search strategy, first, a total of 368 articles were retrieved from four databases. 218 duplicates among the databases were excluded. Then, the abstract and title of 150 articles were studied according to the inclusion criteria. In this time, 58 articles remained for the next investigation; then, 92 records were excluded. Next, the full-texts of 58 articles were investigated. Finally, 23 related articles were included in the final analysis of the study. The process of selecting articles is shown in Figure 1.

3.2. Characteristics of studies

3.2.1. Publish year

All included articles were published from 2015 onwards. Researchers have been considering the latest ten-year period to access more recent articles because older studies have focused mainly on tools such as phone calls or SMS services.

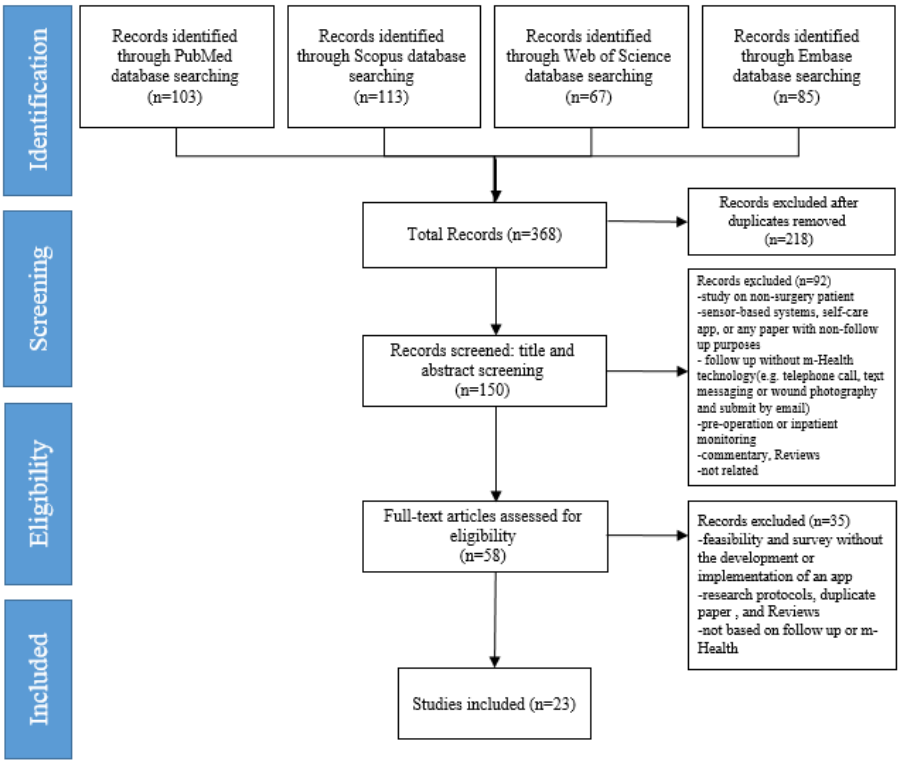


Figure 1. The PRISMA-based article selection process flow chart

3.2.2. Surgeries studied

Studies are not limited to specific surgeries and have been designed and evaluated follow-up programs for a variety of outpatient and inpatient surgeries. Examples included general surgery [3, 7, 8, 13-17], gynecology [18, 19], orthopedics [3, 13, 20-23], cardiac [4], ENT [13, 24], neurosurgery [9], and urology [6].

3.2.3. Follow-up period

Among the studies that referring to the follow-up time period, eight studies up to 14 days [9, 10, 13, 15, 22, 23, 25, 26], six studies a thirty-day period [3, 8, 16, 18, 19, 21], four studies one to three months [4, 6, 20, 24] and in the one study [17] related to cancer surgery, more than three months' follow-up established.

3.3. Components of apps

Components and dimensions of programs as summarized are presented in table 2.

3.4. The most important findings of studies

Main findings and the most important achievement of studies are summarized in table 3.

Table 2. Main components in the developed mHealth-based applications for patient follow-up

Component / Study	Evaluation of recovery quality		Pain assessment (by VAS[3])	Uploading clinical data		Contact with care provider & Consult	Reminder & alerts	Education/ discharge instruction
	QoR [1]	Other indicators [2]		wound image	other			
[1, 13, 25]	√					√		
[3, 8, 20]	√	√	√	√				
[9]		√	√					
[10, 14]		√		√				
[15]				√		√		
[23]		√	√					
[18]		√	√	√				
[24]							√	√
[7]		√		√				
[16]		√	√	√			√	
[19]		√					√	√
[26]						√		√
[22]		√		√	√			√
[17]				√	√	√		√
[27]		√	√					
[21]		√	√	√		√	√	
[4]		√			√		√	√
[6]		√	√				√	√

1. Quality of Recovery Questionnaire. 2. Questions related to specific surgery or symptoms of infections. 3. Visual Analogue Scale

Table 3. The most important achievement of studies

Categories	References	Description
Feasibility	[3, 6, 8, 10, 16, 18, 19, 22]	The use of a mobile-based app technology for postoperative follow-up to be feasible and applicable.
Patient satisfaction and positive attitude	[1, 3, 6, 9, 10, 13-16, 20, 21, 23, 27]	In most studies, patients and care provider's satisfaction with using mobile-based follow-up apps was reported. In addition, the apps have been easy to use.
Facilitating early detection of complications	[3, 7, 10, 15]	Early identify along with timely intervention is one of the most important effects of follow-up programs, that help to reduce hospital readmission and unexpected visits.
Reducing in-person or unscheduled visits	[8-10, 15, 20, 25]	This new modality for follow-up care can potentially reduce or minimize the number of in-person and inpatient visits. It can potentially prevent readmissions.
Improving adherence to instructions	[6, 18, 24]	Adherence to postoperative instructions and treatment is improved with using programs.
Improving patients' self-care	[13, 17, 19, 21]	It leads to patients' active participation in caregiving, then self-efficacy and responsibility for self-care are promoted.
Cost-effectiveness	[15, 25]	Some studies found that smartphone-based apps for measuring the quality of recovery were cost-effective.

4. Discussion

A growing number of recent studies have shown the utilization of mobile apps as a new modality that provides support for follow-up programs and monitoring recovery [17]. This study`s main goal was a general review of articles to identify mHealth-based apps developed for post-discharge follow-up of surgical patients.

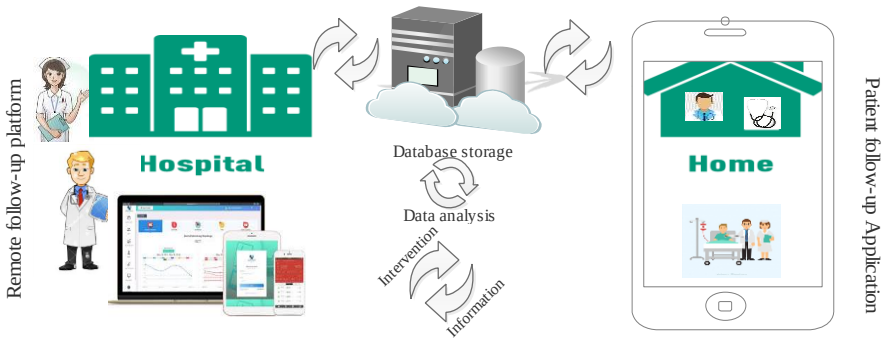
According to Table 2, most of the used and repeated components in the studies include measuring the quality of patients' postoperative recovery, evaluation of pain level with VAS, and recording images of the surgical site for wound monitoring. Remote surveillance of surgical site infections for surgical patients is a necessary component. Uploading images of the wound in the app, along with answering questions about the signs and symptoms of the infection, can help to detect the infection early enough.

Different questionnaires are used to evaluate patients' recovery, most of which are derived from the standard QoR questionnaire [28]. Different versions of this questionnaire have been developed in studies, depending on the type of surgery or the purpose of the study [1, 3, 20].

Based on the evidence, the use of a mobile app for postoperative follow-up to be feasible, as well as it will bring patients and health provider satisfaction and can be effective in early detection of complications, reduction in readmission, improving adherence to postoperative instructions, and patients' self-efficacy. Ultimately, it is potentially useful in optimizing the quality of recovery. This may reduce related costs.

The results of previous review studies were similar to our findings. For example, Williams et al, in a narrative review, found that the role of telemedicine technology has become increasingly importance in postoperative care. It indicated excellent clinical outcomes, decreased driving distance and wait times, as well as a high degree of patient satisfaction and cost savings to both the patient and health system [29]. In another study by Lu et al, systematically reviewed using short message service and smartphone apps in the management of surgical patients. This review found that these interventions can accurately and efficiently evaluate surgical patient symptoms postoperatively, as well as improve patient adherence to protocols, improve clinic attendance, also have the potential to reduce healthcare costs [30]. Another systematic review that studies the using smartphones and tablets in surgery, demonstrated a wide range of innovative utilities in the pre-, intra-, as well as postoperative contexts. Although studies clearly highlight the substantial potential of these devices in the surgical setting, future trials whit greater quality was recommended [31].

Generally, this method of tracking has many potential benefits for surgical patients' care management, but it does not mean regular follow-up method replacement [17, 32]. A combination of this approach with the usual care manner can be beneficial.



- Patient education in accordance with discharge instructions, Recording patient-centered clinical documents, Virtual visits, Reminders, Notifications, Communication with healthcare providers, Teleconsultation, Link to outpatient centers and home nursing services.
- Surveillance on remote visits by the fast-tracking control panel and automatic monitoring with rule-based smart dashboards.

Figure 2. Suggested components for post-discharge care and systematic follow-up programs

Although we do not claim that this review study is comprehensive, it can be useful as evidence for future research of other researchers in this domain. Also, we hope that these findings as well as suggested components (Figure 2), help developers of programs.

5. Conclusions

Our review showed that mHealth-based interventions have potential that may support better management of post-discharge systematic follow-up. Therefore, planning to make more utility of this technology to support standard care especially in outpatient surgeries is recommended. Although these new approaches could be effective, qualitative and quantitative evaluations with clinical trials and before and after studies are necessary.

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