



## Smartphone app for asthma self-management – a literature review of contents and functions

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### ABSTRACT

A self-management is an important thing in achieving optimum health outcomes. One of the many effective ways that help improve the outcomes of self-management in asthma is through the use of smartphone applications or popularly known as apps. The apps have been designed to help patients in controlling asthma complaints. This study aimed to examine contents and functions featured in the reviewed studies as well as to suggest what functions and contents should be featured in an asthma self-management smartphone app. This study used a systematic approach to examine and review the contents and functions of asthma management apps from selected studies. Inclusion criteria of the study included studies related to the use of asthma control or asthma self-management apps, providing information about contents and features of asthma apps, apps in the reviewed studies designed for laypersons or patients, studies published in peer-reviewed scientific journals in English, and original articles. All the studies had been taken from 2013 to 2018 from three databases, namely Pubmed, Science Direct, and ProQuest. Exclusion criteria included full text unable to be accessed and unable to obtain complete full statistical data. Results of this study showed that the most popular functions and contents featured in the asthma apps involved asthma education, medication use monitor, medication reminder, asthma control test, peak flow meter, asthma symptom monitor, and asthma action plan. Less popular functions and contents included a chat with others, Air Quality Health Index, and Quality of Life Questionnaires.



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### INTRODUCTION

Asthma can simply be defined as a chronic or long-term inflammatory medical condition of the airways commonly characterized by shortness of breath, coughing, wheezing, pressure, pain, and chest tightness. The Global Initiative for Asthma (GINA) has reported more than 300 million people around the

world to have asthma complaints. There is no exact cure for asthma, but The American Academy of Allergy, Asthma, and Immunology suggested that patients with asthma will be able to manage their health condition and improve their quality of life once their asthma complaints are properly diagnosed and a treatment plan is in place (Wood *et al.*, 2017).

A self-management is quite critical to achieving optimum asthma treatment goals. The Latest studies have found that training in asthma self-management, which involves a number of varied factors, such as a self-monitoring activity, a regular medical review, and a written action plan, appears to improve health outcomes for patients with asthma (Mirabelli *et al.*, 2015). One of the many effective ways proposed to help improve the outcomes of self-management in patients with asthma is through the use of smartphone applications. The applications have been designed to help patients make matters better and control their asthma complaints. In addition to widely available and easily operated, the apps also offer varied communication methods and are relatively inexpensive. By using an asthma app, patients will easily record their symptoms and identify possible triggers. A doctor or specialist then can simply use the information of symptoms and triggers to help patients prevent further worsening conditions (Cook *et al.*, 2016).

A smartphone application, popularly referred to as a mobile application or an app, is a type of application software designed to run on a smartphone, tablet PC, or other portable mobile devices. The applications are commercially available on the App Store (Apple iOS) and Google play store (Google Android OS). The number of smartphone users grows rapidly every year. In January 2018, according to the new 2018 Global Digital suite of reports from We Are Social and Hootsuite, there are more than 5.135 billion unique smartphone users around the world, and the penetration has reached 68%. The reports also confirmed that there were 2.958 million active mobile social users with 39% penetration ("Digital in 2017," n.d.). Another report showed that the total number of Apple iOS app downloads in 2016 was 25 billion, while Google Android OS app was 90 billion. Additionally, an updated systematic assessment of content and tools published in 2015 in the BMC Medicine stated that there were 764 smartphone apps commercially available at the store, specifically 538 on Google Android OS play store and 226 on Apple iOS app store (Belisario *et al.*, 2013).

Information and communication technologies help people in providing regular care and informa-

tional support, therefore improving health outcomes. Many health care professionals have used smartphone applications as a way to educate or help patients to manage their health problems. In addition, the applications also make mobile devices invaluable tools in supporting clinical decision-making at the point of care (Ozdalga *et al.*, 2012). The primary objective of this article is to suggest what functions and contents should be featured in an asthma self-management smartphone app. This study used a systematic approach to examine as well as to review both content and function of asthma management apps from selected studies.

## MATERIALS AND METHODS

### Search Strategy

This literature review began by searching for peer-reviewed original articles that are available at the following electronic databases: PubMed, ProQuest, and Science Direct. All the articles were published between January 2013 and July 2018. Search terms used in this study primarily involved various combinations of the following terms "asthma", "asthma management", "self-management", "asthma self-management", "control", "mobile", "phone", "mobile phone", "smartphone", "app", and "applications".

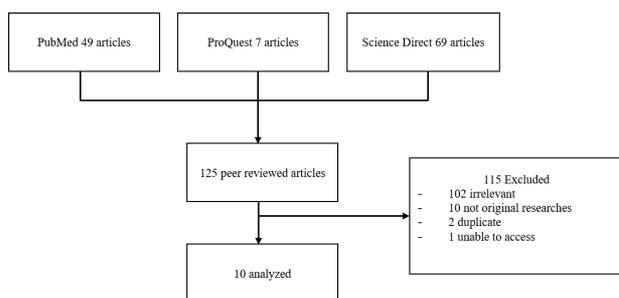
### Study Selection

We selected peer-reviewed articles from electronic databases using the following criteria, as shown in Table 1 below

We found 125 peer-reviewed original articles for our assessment. However, 115 articles were excluded when further reviewed. The primary reasons were the articles did not examine the use of asthma self-management smartphone apps, not provide information about the contents and functions of asthma self-management, or the studies did not specifically discuss about asthma. Additionally, there were 2 articles removed due to duplication. Therefore, we analyzed 10 articles in total for this function and content assessment (Table 1). Data extracted included contents and functions featured in the asthma management smartphone apps (i.e. text and video-based education about asthma, medication usage, patient health status, medication reminder, a written asthma action plan, and asthma action plan score.). Other data examined by authors involved subjects of study, duration of the study, type of study, location of the study, and type of Operating System (OS) that were run during the studies. Figure 1 below shows the process of peer-reviewed article selection conducted in this literature review.

**Table 1: The inclusion and exclusion criteria of the literature review**

Inclusion	Exclusion
Articles related to the use of asthma control or asthma self-management apps.	Full text unable to be accessed
Articles providing information related to contents and features of asthma app/apps.	Unable to obtain complete full statistical data.
App/apps in the articles designed to be used primarily by laypersons or patients.	
Articles published in the peer-reviewed scientific journals in English.	
Original articles.	



**Figure 1: Process of peer reviewed article selection**

**RESULTS AND DISCUSSION**

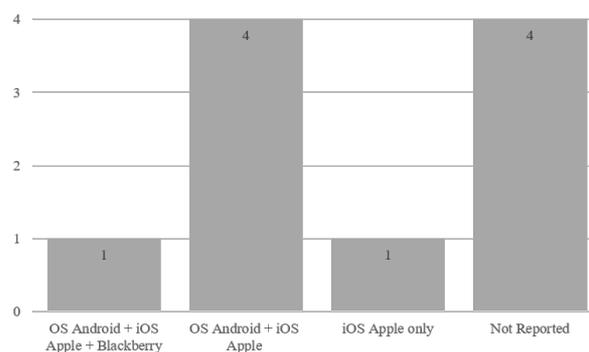
**Subject and Study Design**

All reviewed studies examined patient’s use of smartphone apps for improving their asthma condition as well as health outcomes. In addition to the patient, this study also involved informal caregivers, such as parents of the patient. Sample sizes of the studies ranged from 7 to 352 subjects, with a mean of 79 subjects and a median number of 47. More than half of the studies used some type of participant randomization (60%; n=6). Three studies (30%; n=3) were feasibility studies, while one (10%; n=1) was a pilot study. The duration of study ranged from 2 weeks to 6 months, with an average intervention length of 14 weeks or 3 months. Most studies (70%; n=7) were located in the United States, while other three studies were taken in Netherland (10%; n=1), South Korea (10%; n=1), and Turkey (10%; n=1).

**Type of Operating System**

Half of the reviewed studies (50%; n=5) run Operating System Google Android, Apple iOS, and BlackBerry. Specifically, four studies (40%; n=4) run both Google Android OS and Apple iOS, whereas one study (10%; n=1) was BlackBerry OS operating system. Additionally, there was only one study (10%; n=1) that run the Apple iOS operating system, whereas four studies 40% (n=4) unfortunately

did not report this information. Figure 2 below shows the type of Operating System (OS) used in all reviewed studies.



**Figure 2: Type of operating system used in the reviewed studies Mobile App Contents and Functions**

More than half of asthma management smartphone applications used in the reviewed studies (60%; n=6) featured asthma education and medication use monitor. The materials of asthma education came in two formats, namely text and video. Other popular app functions featured in the studies were an asthma control test and medication reminder. This study found that half of the asthma management smartphone apps (50%; n=5) used in the reviewed studies featured both functions in their content.

Nearly half of asthma management smartphone apps (40%; n=4) used in the reviewed studies featured asthma symptom monitor and peak flow meter function. In one reviewed study, the asthma monitor did not only measure asthma symptoms but also medication and activity of the users. Other functions featured in the asthma management smartphone apps included asthma action plan (30%; n=3) and chat with others (20%; n=2).

Less popular asthma self-management smartphone app functions were the Air Quality Health Index (AQHI) information and Quality of Life Question-

naire for Adult Korean Asthmatics or QLQAKA for short.

The use of smartphone apps for improving a health condition or guiding healthy lifestyle is increasing rapidly. However, research about the contents and functions featured in the asthma management smartphone apps seems relatively small. This study highlights a number of those apps that have been used to help patients manage their asthma complaints as well as improve their health outcomes. Additionally, the study also examines contents and functions featured in the apps to make a suggestion for app developers in collaboration with health care professionals what contents and functions to feature into an asthma management smartphone app.

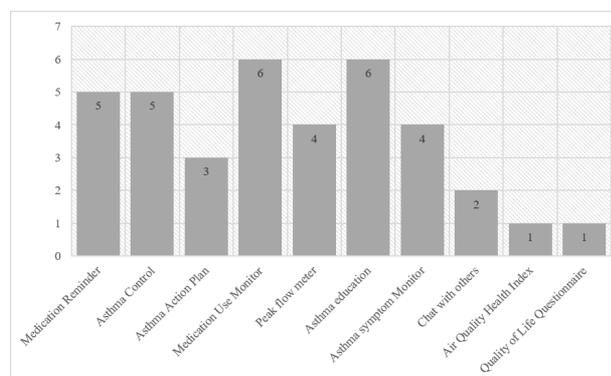
Most of the apps, as shown on Figure 3, featured asthma education and medication usage monitor, which means that the apps were developed for self-education and self-monitor purposes. A review published in 2013 reported that self-monitoring and self-assessment function featured in the asthma apps helped improve outcomes as well as education of patients (Belisario *et al.*, 2013). It means that an ideal asthma management smartphone app should feature asthma education and medication use monitor. An asthma education function, as its name suggests, explained asthma to patients including basic knowledge about asthma, such as signs, symptoms, potential triggers, medications, preventive actions, the use of an inhaler and peak flow meter, and asthma self-management. Meanwhile, a medication usage monitor function helped patients in monitoring their medication use. This function is quite helpful in tracking the medication use of patients, therefore, preventing them from forgetting or skipping doses as well as improving medication adherence.

An Asthma Control Test (ACT) function is useful in examining the asthma condition of the users, whereas medication reminder helped in improving medication adherence. An asthma control test feature consists of five questions describing how well the asthma condition has been controlled in four weeks. Each question has a minimum score of 5 and a maximum of 25. There are three categories in the asthma control test, namely "well done" (25), "on target" (20 - 24), and "off-target" (less than 19). A "well done" score means that asthma symptoms appear to have been under control over the last four weeks, whereas "on target" describes that asthma symptoms appear to have been reasonably well controlled during the past four weeks. The last score, known as "off-target" shows asthma symptoms that have not been under control during the past four weeks. A medication reminder

function featured in the asthma management smartphone apps used in the reviewed studies is very useful as user engagement in addition to remembering patients to take their personal asthma medications, thus improving medication adherence. A study published in 2003 has defined adherence as "the amount of time a patient takes a given medication as prescribed" (Jones *et al.*, 2003). Regarding the function of the feature, this may be one of many good reasons why using a smartphone application helps improve patient's adherence in taking their asthma medications.

A peak flow meter function can provide information related to the rate of peak expiratory flow. It alerts patients to the tightening of the airways in hours or days before having asthma symptoms. This function is also useful for patients in learning things or triggers that provoke asthma symptoms, measuring whether asthma action plan is working well or not, deciding the time for adding or adjusting medications, as well as the time for seeking doctors, specialist, or professional emergency care. The higher the peak flow levels, the better the asthma condition is.

Asthma action plan, or known as an asthma management plan, is a written instruction given by a doctor or specialist for patients about the ways to get rid of as well as to prevent asthma attacks. This is helpful for patients in controlling asthma attacks in the future. Each person may have different asthma action plan form in common, but ideally it should cover the following information: symptoms experienced by patients and what actions to take if the symptoms occur, a list of known and possible asthma triggers, what and when asthma medications should be taken by patients, ways to manage flare-up symptoms, and the time to get professional medical care.



**Figure 3: Smartphone app content and function featured in the reviewed studies**

**Table 2: List of peer-reviewed studies about asthma-self management smartphone apps**

Author, Year	Subjects	Duration of Study	Type of Study	Study Location	OS Type	Contents and Functions
(Fedele et al., 2018)	50 poorly controlled early adolescents + 1 caregiver	4 months	A randomized controlled trial	United States	None	Assessment of asthma management behaviors and allocation of treatment responsibility (such as medication use), collaborative asthma management features (such as parental monitoring and supervision, parental involvement, family functioning, behavioral management, disease and treatment knowledge, determining health care needs, peer support, and patient-provider communication), skill-training videos how to use the app, complete the real-time assessment process, and collaborate on asthma management, and self-guided asthma control features.
(Cushing et al., 2016)	7 adolescents (4 used adherence sensors, while 3 used smartphone app + sensors)	12 weeks	A feasibility study	United States	iOS (Apple and iPod)	Medication usage viewer, reminder, graphic displays about medication adherence (daily, weekly, monthly), and a customizable avatar & a gift card.
(Rhee et al., 2014)	16 adolescent-parent dyads	2 weeks	A feasibility study	United States	None	Customizable text-messaging based features such as user's daily routine, specific medications, medication schedules, daily asthma-monitoring inquiries (symptoms, medications, activity), and medication reminders.
(Kim et al., 2016)	44 patients	8 weeks	A feasibility study	South Korea	None	A written asthma action plan, recorder of asthma symptoms and peak expiratory flow, Asthma Control Test, Adherence of medication by self-assessment, and Quality of Life Questionnaire for Adult Korean Asthmatics.

*Continued on next page*

Table 2 continued

(Cingi <i>et al.</i> , 2015)	89 patients	3 months	A multicenter, randomized, controlled, double-blind study	Turkey	None	Patient health status tracker, motivational and educational content, medication usage reminder, interactive health status update, and Asthma Control Test.
(Perry <i>et al.</i> , 2017)	34 patients	6 months	A randomized clinical trial	United States	iOS and Android	Personalized Asthma Action Plan for routine and worsening asthma symptoms; Daily medication reminders; Monthly prescription refill reminders; Self-management tips, such as trigger avoidance; and Electronic peak flow and/or symptoms diary.
(Liciskai <i>et al.</i> , 2013)	22 patients	81 days	A prospective, single-center, non-randomized, pilot pre-intervention-post-intervention analysis.	United States	iOS, Android, and BlackBerry	Air Quality Health Index (AQHI) information; AQHI Forecast for Tomorrow; Breathing Test; Today's Symptoms; Your Current Zone; Your Asthma Action Plan; and Breathing Test Graphs.
(Cook <i>et al.</i> , 2016)	58 patients	4 months	A prospective, single-center, non-randomized, pilot pre-intervention-post-intervention analysis.	United States	iOS and Android	An extensive collection of evidence-based educational materials (written format and videos) containing discussion of triggers, importance of medication adherence, the role of different medications, inhaler technique and troubleshooting, use of a peak flow meter, and management of acute symptoms; proactive alerts containing requests for self-assessment of asthma control, assessment of patient knowledge regarding asthma self-care, and resulting individualized coaching based on their previous entries; and assessment of asthma control.
(Kosse <i>et al.</i> , 2017)	352 patients	6 months	A community pharmacy-based cluster randomized controlled trial.	Netherlands	iOS and Android	A questionnaire function to rate asthma symptoms and monitor these over time; short movie clips with medication and disease information; a medication reminder; a chat function with peers; and a chat function with the pharmacist.
(Barrett <i>et al.</i> , 2017)	120 patients	30 days	A single-arm pilot study.	United States	iOS and Android	Objective assessments of asthma control; adherence; potential triggers; asthma education; and collected data and summary report reviewer.

A combination of asthma peak flow meter and asthma action plan will help users know when to take asthma medicine, especially quick-acting inhaler. Asthma action plan commonly has three major zones, which are based on three colors of a traffic light, namely red, yellow, and green. A red zone represents a danger condition, which explains what actions to take when asthma flare-ups are severe. The yellow, or known as a caution, explains the way to look for worsening asthma symptoms. The last is green, which explains the ways to manage asthma in good condition (Bhokal et al., 2006).

A “chat with others” function helps patients in making a conversation with other people (i.e. family members, friends, doctors, specialists, pharmacists, nurses, and other health care professionals.). In one reviewed study, a “communication with others” function was included in the collaborative asthma management feature (Kosse et al., 2017). Clear communication is important in asthma management. It is quite useful for patients in improving the quality of asthma control, action plan, asthma outcomes, asthma knowledge, as well as an asthma treatment plan.

Less common functions featured in the asthma management smartphone apps included the Air Quality Health Index (AQHI) and Quality of Life Questionnaire for Adult Korean Asthmatics (QLQAKA). The AQHI is a scale that helps understand the quality of air around patients. The quality of air may influence the patient’s health. In the reviewed study, the AQHI basically has two main features, namely information and forecast. Adding AQHI function into the asthma management smartphone apps seems to be a good decision. However, not all countries have this tool. It can be an optional function to be featured in the asthma management smartphone apps. The QLQAKA is a tool containing a number of questionnaires, which reflect the cultural and behavioral properties of the patient living in South Korea. It primarily has 4 domains, namely symptoms, daily activity, emotion, and reaction to environmental stimuli. This tool was designed for Korean asthma patients. For other countries, it can be replaced with valid and reliable Asthma Quality of Life Questionnaire (AQLQ). Table 2 below shows a list of peer-reviewed studies related to smartphone app-based asthma self-management.

## CONCLUSIONS

The result of this study concluded that there were 10 functions that should be featured in an asthma management smartphone app. The functions involve asthma education, medication use monitor, asthma

control, medication reminder, asthma symptom monitor, peak flow meter, asthma action plan, chat with others, Air Quality Health Index (AQHI), and Asthma Quality of Life Questionnaires (AQLQ). Smartphone app developers, in collaboration with health medical professionals, may find it useful to design and develop an asthma management smartphone app. Further research is needed to develop an asthma management smartphone app that is complete, easy to operate, and the important, clinically able to improve health outcomes.

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