Sys Rev Pharm 2020;11(12):984-993
A multifaceted review journal in the field of pharmacy

A Systematic Content Review of Google Android OS-Based Asthma Self-Management Apps in Indonesia

Apt. MT Ghozali, M.Sc.[1,2], Dr. apt. Satibi, S.Si., M.Si.[3],
Prof. Dr. apt Zullies Ikawati[4], Dr. Lutfan Lazuardi, M.Kes., Ph.D[5]

1, 2 Doctoral Graduate Program, Faculty of Pharmacy, Universitas Gadjah Mada, Yogyakarta, Indonesia,
3 Department of Pharmaceutics, Faculty of Pharmacy, Universitas Gadjah Mada, Yogyakarta, Indonesia,
4 Department of Pharmacology and Clinical Pharmacy, Faculty of Pharmacy, Universitas Gadjah Mada, Yogyakarta,
5 Department of Health Policy and Management, Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada,
Corresponding author: Satibi, satibi@ugm.ac.id

ABSTRACT

A lot of asthma self-management apps were commercially available on the market; however, they make potential users confuse to decide which one is suitable for them. This study was aimed to analyze the contents in the asthma apps available in Indonesian Google Playstore. This study utilized a systematic approach to analyze the contents of asthma self-management apps during February to March 2019. It was started by filtering apps with specific keywords including "asthma", "asthma control", "asthma control test", "asthma relief", and "asthma education". Inclusion criteria included apps built specifically for asthma, available for download from Google Playstore, should be in English, free of charge, and rated 4-star or above. Exclusion criteria included all asthma apps that required invitation from publisher to use, were unable to be tested due to technical difficulties, and developed not for patients. All selected apps were then analyzed and examined for the contents. This study found that most asthma self-management apps contain various degrees of asthma education ranging from medical to alternative treatment, list of medication, medication usage, asthma control test, asthma action plan, asthma diary, and symptom monitor. Less popular contents included peak flow recorder, game-based asthma quiz, and lung function. An ideal asthma self-management apps should feature asthma self-management education appropriate with international guidelines and involving health care professionals, symptom monitor including peak flow readings, list of medication, medication usage, asthma action plan, and asthma control test.

Keywords: Asthma, asthma self-management, smartphone apps, Google Android apps

Correspondence:
Satibi,
Department of Pharmaceutics, Faculty of Pharmacy, Universitas Gadjah Mada, Yogyakarta, Indonesia,
*Corresponding author: Satibi, email-address: satibi@ugm.ac.id

INTRODUCTION

Asthma is described as a long-term or chronic inflammatory disease of the airways of the lungs, generally characterized by varying levels of constriction of the airways in the lungs[1], hyper-responsiveness of the airways, chronic inflammation, chest tightness, and excessive mucus secretion[2,3,4,5]. Estimates vary, but recent studies showed more than 300 million people in the world have asthma complaints[6]. The primary causes of asthma are not known clearly, however, the condition occurs when breathing tubes carrying air in and out of the lungs get inflamed. It leads the tubes highly sensitive; therefore, narrowing temporarily. There is no exact cure for asthma but supported self-management can help in improving clinical outcomes[7,8].

The implementation of smartphone apps in modern daily activities is now growing rapidly. In addition to communication purposes, it also allows users to run the apps and to browse internet and other data networks[9,10]. In some daily routines, it can replace some functions of PC desktops or laptops, such as arranging or managing daily tasks, playing video games, taking or editing multimedia including photos and videos, as well as processing and sharing documents. A number of various smartphone apps are available for users to download. It is reportedly more than 8,000 mHealth applications have been developed for smartphones[11]. In the health care, the implementation of the apps has been demonstrated in a research context. The use of portable gadgets for medical purposes is popularly known as mobile health (mHealth). With this technology, health care providers are able to do their professional services over long distances, while patients have faster access to the services.

The international clinical guidelines highly recommend involving education related to asthma self-management to support asthmatics[12]. A good education can help improve the levels of asthma control, asthma-related health outcomes, as well as reducing medication usage and health care resources[13,14]. However, implementing education for asthmatics in clinical practice is not an easy task.

An asthma self-management app is now becoming an important thing since the app provides a promising opportunity related to improving the quality of asthma control levels and self-management in people with asthma. It allows medical professionals to make a conversation with or giving education to their patients without facing problems related to distance and time. Additionally, it also offers a number of services, such as recording recent condition, symptoms, the use of medications, as well as improving knowledges about asthma self-management. This is one of good reasons why it is important to develop an asthma self-management app involving professionals. This study outlines the contents in the asthma self-management apps available in the Indonesian Google Playstore. It is a new study and no previous study was available in Indonesia. This is why the authors hope that it can be an insight or idea for app designers regarding to what contents should be included in a clinically standardized asthma self-management smartphone app.

METHODS

A list of asthma self-management apps was collected during February 2019 using the search feature found at the Android App on Google Play web at: https://play.google.com/store/apps. The search terms

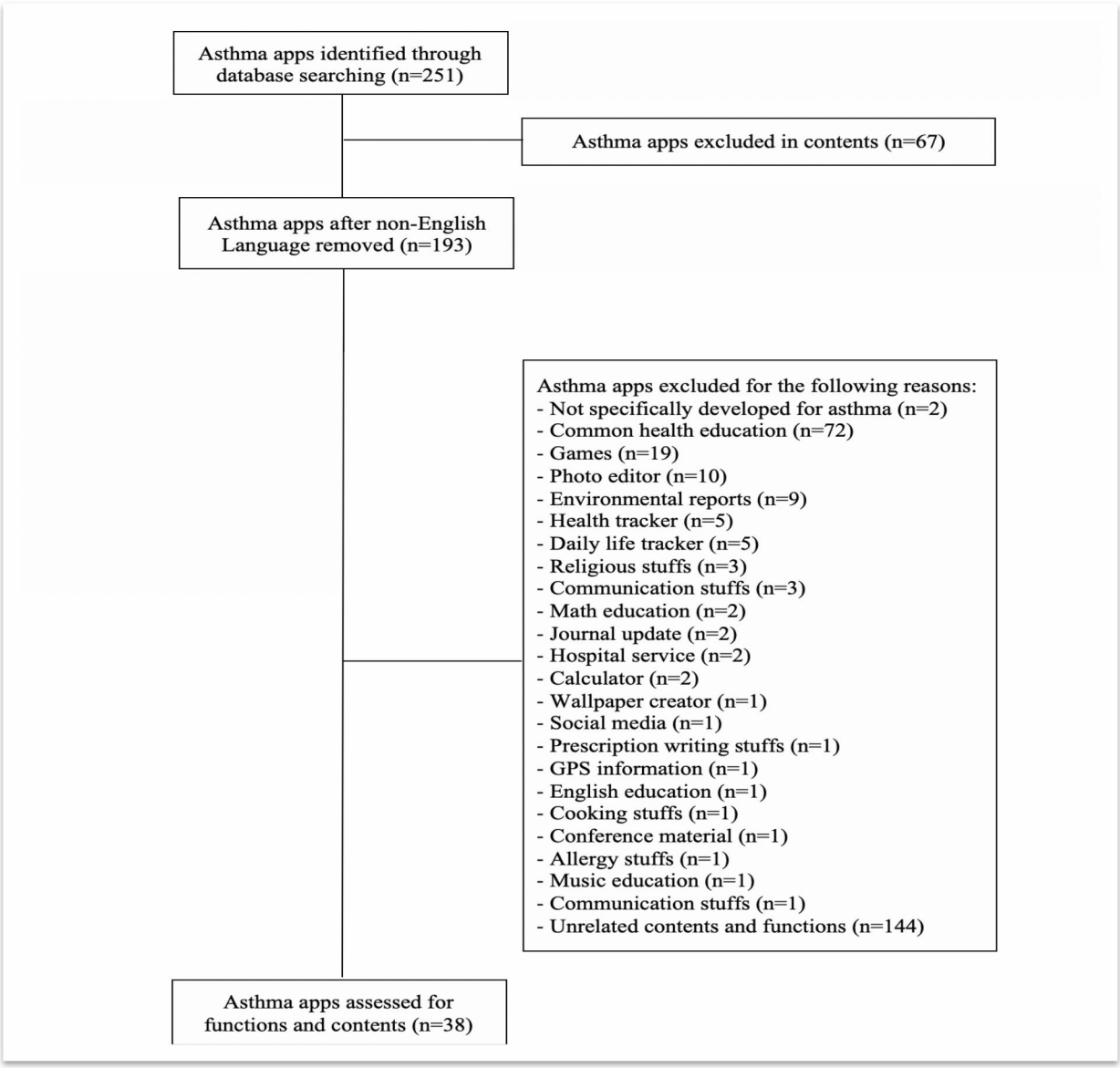
used in this analysis included keywords related to asthma condition, such as "asthma", "asthma control", "asthma control test", "asthma relief", and "asthma education". Devices used during test included a Google Android tablet and a PC desktop installed with BlueStacks®. Table 1 represents the criteria of the study.

Table 1. The inclusion and exclusion criteria of the study

Criteria	Description
Inclusion	• Smartphone apps. • Apps were developed specifically for asthma only. • Apps are available for download from official app stores of Google. • Apps should be in English language. • Apps are free of charge. • App ratings are 4 or above.
Exclusion	• Requires invitation from publisher to use. • Unable to be tested due to technical difficulties. • Apps were developed not for patients or laypersons.

The authors, before selecting apps, conducted a preliminary search to identify app types. In this study, we focused on the contents in the selected apps, including text and multimedia-based asthma education, asthma diary, recorder of peak flow, medication usage, and asthma action plan as a minimal indicator of a clinically standardized asthma self-management smartphone app. Additionally, we also highlighted the app developers, app ratings (4-stars or above), and latest update information of the selected apps. Figure 1 represents a procedure for selection of sample of asthma self-management apps utilized in this study.

Figure 1. Procedure for selection of sample of Asthma Self-Management Apps



RESULT

A total of 251 asthma self-management apps were identified; however, 213 apps were excluded due to following reasons: 144 apps had unrelated contents (for example, music education, math education, games, education about stress relief, yoga exercise, wallpaper creator, health benefits of foods, and common health education.), 67 did not use English (for example, Tamil, Urdu, Arabic, Chinese, Italy, Greek, and Indonesia), and 2 were not specifically built for asthmatics. The final sample consisted of 38 asthma apps for content analysis. A summary of the results was shown in Table 2.

Table 2. Profiles of Selected Google Android Asthma Management Apps

NO	APP NAME	DEVELOPER	USER RATINGS	LATEST UPDATE
1	Asthma MD	AsthmaMD	4.2	2-Oct-18
2	Asthma Relief - Acupressure	Dr. Jakob Bargak	4.3	26-Oct-14
3	SaniQ Asthma	Qurasoft GmbH	4.1	18-Feb-19
4	Asthma	Health care IT	4.2	1-Nov-17
5	SOS-Asthma	ID Mobile SA	5	28-Sep-18
6	Asthma	dagana Apps	5	29-Sep-18
7	Asthma: Causes, Diagnosis, and Treatment	Health Info	4.5	1-Sep-18
8	Peak Flow	Ben Hills		26-Apr-18
9	PRAM Score - Pediatric Asthma	Ontario Lung Association	4	14-Oct-15
10	Asthma Protocols	Dr.Isaac's Holistic Wellness	4.3	3-Dec-18
11	Home Remedy for Asthma	StatesApps	4.2	30-Dec-17
12	Asthma Medications	FluffyCuteApps	5	3-Nov-18
13	Asthma	K R JAWAHARLAL	4.3	27-Oct-15
14	Asthma Management	Pulmonary Medicine	4.6	16-Jun-18
15	7 keys to manage Child Asthma	Chainsys	5	20-Sep-18
16	Treatment of asthma	Pen Drouzi	4.8	15-Nov-18
17	Asthma & Me	Training Systems Design, Inc.	4.1	21-Dec-18
18	Asthma Inhaler Assistant	CCHMC Learning Sciences	4.7	30-Dec-16
19	Asthma (PLUG)	YogaNipat.com	4.5	3-Jan-14
20	7pranayama: Yoga Daily Breath Fitness Habit - Calm	Pixelpointtechnology.com	4.6	16-May-18
21	Pulmoment	Dániel Eke	4.3	22-Aug-18
22	Prana Breath: Calm & Meditate	Oleksandr Albul	4.8	30-Nov-18
23	Asthma Educator Exam Quiz	NUPUIT	5	26-Jun-18
24	ASTHMAXcel	Montefiore Applications, LLC	4.9	25-Jul-18
25	Asthma treatments, symptoms and triggers	round.glass	4.6	8-May-18
26	AsthME	QuantifiedCare	5	19-Jun-17
27	SAWBO Inhaler	University of Illinois	4	2-Dec-14
28	Asthma Help	Dusko Savic	5	17-Apr-16
29	use-inhalers	Learn To Drill	5	15-Oct-18
30	Breathe - 1 minute Breathing Exercise	Shantha Technologies	4.7	8-Jan-19
31	Yoga and Therapy	Chetan Rajkumar Ingle	5	15-Jan-17
32	Pranayama Yoga With Timer	YellowCup	4.2	11-Sep-16
33	Yoga for Beginners | Workouts for the mind & body!	Workout Apps	4.6	1-Feb-19
34	Breathing Yoga Pranayama	MediApps	4.6	11-Jan-19
35	Yoga for Beginners – Daily Yoga Workout at Home	ANDROID PIXELS	4.5	6-Feb-19

36	Respiratory diseases & respiratory therapy	قنية نت	5	3-Aug-18
37	Aria: Home Spirometry & Lung health Assistant	Nuvoair AB	4	29-Jan-19
38	AIRBRIO®	Airbrio	5	16-Nov-17

The authors had selected 251 apps, and there were only 38 that met the criteria. Over half of the selected apps (60%; n=24) contained educational materials in which 20 apps were text-based educational materials with pictures while 4 apps were multimedia-based types. Another popular content was symptom monitor. It was found two apps that featured symptom monitor into their functions. Table 2 summarizes the contents of asthma self-management apps.

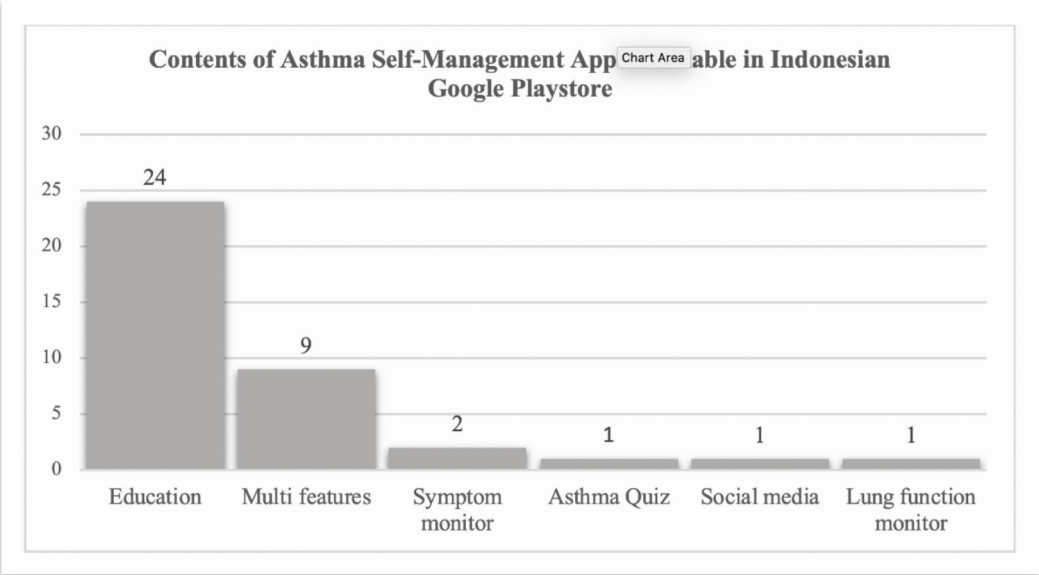
Table 2. A summary of contents of asthma self-management apps

NO	APP NAME	CONTENTS AND FUNCTIONS
1	Asthma MD	• Personal asthma journal keeper. • Color graph visualization of asthma activity. • A shareable asthma diary. • Asthma research (education). • Multiple user. • Medication list. • Tracker of medication action. • Peak Flow Meter (PFM) mapper. • Tracker of asthma trigger. • FEV1 or PulseOX data tracker.
2	Asthma Relief - Acupressure	Video and photo-based education about Traditional Chinese Massage for relieving asthma
3	SaniQ Asthma	• Recorder of peak flows, one-second capacity or FEV1, weight and oxygen saturation. • Bluetooth based recorder of medical measurements. • Shareable health diary. • Memory of medication usage. • Management of medicine supply. • Pollen flight information. • Therapy documents, findings, and emergency plan storage.
4	Asthma	Multimedia based information about asthma
5	SOS-Asthma	Community for asthma patients
6	Asthma	Text based education about asthma knowledge
7	Asthma: Causes, Diagnosis, and Treatment	Text based education about asthma knowledge
8	Peak Flow	• Peak flow meter recording. • Medication usage recording. • Shareable weekly/monthly peak flow graph. • Asthma zone calculator. • Data export.
9	PRAM Score - Pediatric Asthma	Asthma zone calculator – medically known as PRAM-Pediatric Respiratory Assessment Measure
10	Asthma Protocols	Text based education about alternative medicines for asthma.
11	Home Remedy for Asthma	Text based education about home remedies for asthma.
12	Asthma Medications	Text based education about asthma knowledge.
13	Asthma	Text based education about alternative medicines for asthma (Yogasana and Pranayama).
14	Asthma Management	• A visual learning experience. • Asthma Control Questionnaire. • Quality Assessment of Application.

15	7 keys to manage Child Asthma	• Text based education about asthma knowledge. • Asthma Action Plan. • Asthma symptoms recorder. • Peak Flow reading. • Personal ID. • Asthma controller list.
16	Treatment of asthma	Multimedia based information about asthma
17	Asthma & Me	Shareable educational short video about asthma knowledge
18	Asthma Inhaler Assistant	• Identifier of an asthmatic controller or rescue inhaler and education on when to use it. • 3 educational games related to asthma medication.
19	Asthma (PLUG)	Interactive education about asthma remedies with alternative exercises.
20	7pranayama: Yoga Daily Breath Fitness Habit - Calm	Interactive education about asthma remedies with alternative exercises.
21	Pulmoment	Recorder and tracker of asthma condition.
22	Prana Breath: Calm & Meditate	Interactive education about asthma remedies with alternative exercises.
23	Asthma Educator Exam Quiz	Asthma educator exam quiz.
24	ASTHMAXcel	Multimedia based information about asthma.
25	Asthma treatments, symptoms and triggers	• Education on how to manage asthma. • Tracking and sharing asthma symptoms. • Insights based on historical data.
26	AsthME	• Weekly check-in. • Asthma Action Plan. • Chat with health professionals.
27	SAWBO Inhaler	Multimedia based information on how to use asthma inhaler
28	Asthma Help	Interactive education about asthma remedies with exercises.
29	use-inhalers	Interactive education about using inhaler properly.
30	Breathe - 1 minute Breathing Exercise	Interactive education about breathing exercises.
31	Yoga and Therapy	Interactive education about asthma remedies with yoga.
32	Pranayama Yoga With Timer	Interactive education about asthma remedies with exercises.
33	Yoga for Beginners | Workouts for the mind & body!	Interactive education about asthma remedies with yoga.
34	Breathing Yoga Pranayama	Interactive education about asthma remedies with yoga.
35	Yoga for Beginners – Daily Yoga Workout at Home	Interactive education about asthma remedies with yoga.
36	Respiratory diseases & respiratory therapy	Interactive education about asthma and treatments.
37	Aria: Home Spirometry & Lung health Assistant	Interactive lung function test.
38	AIRBRIO®	Data empowering users and enabling them to improve inhalation technique, adherence to prescription regimen, and promote clinical best practices for inhaler-spacer use.

Nearly 25% of the selected apps (n=9) has multi-contents. The contents vary but may include personal asthma diary, asthma education, list of medication, medication tracker, peak flow meter, tracker of asthma trigger, asthma control questionnaires, personal asthma action plan, personal ID, symptom recorder, interactive games related to asthma medication, etc. Less popular functions include social media for asthmatics and lung function. Figure 2 was a list of contents of selected asthma self-management apps in this study.

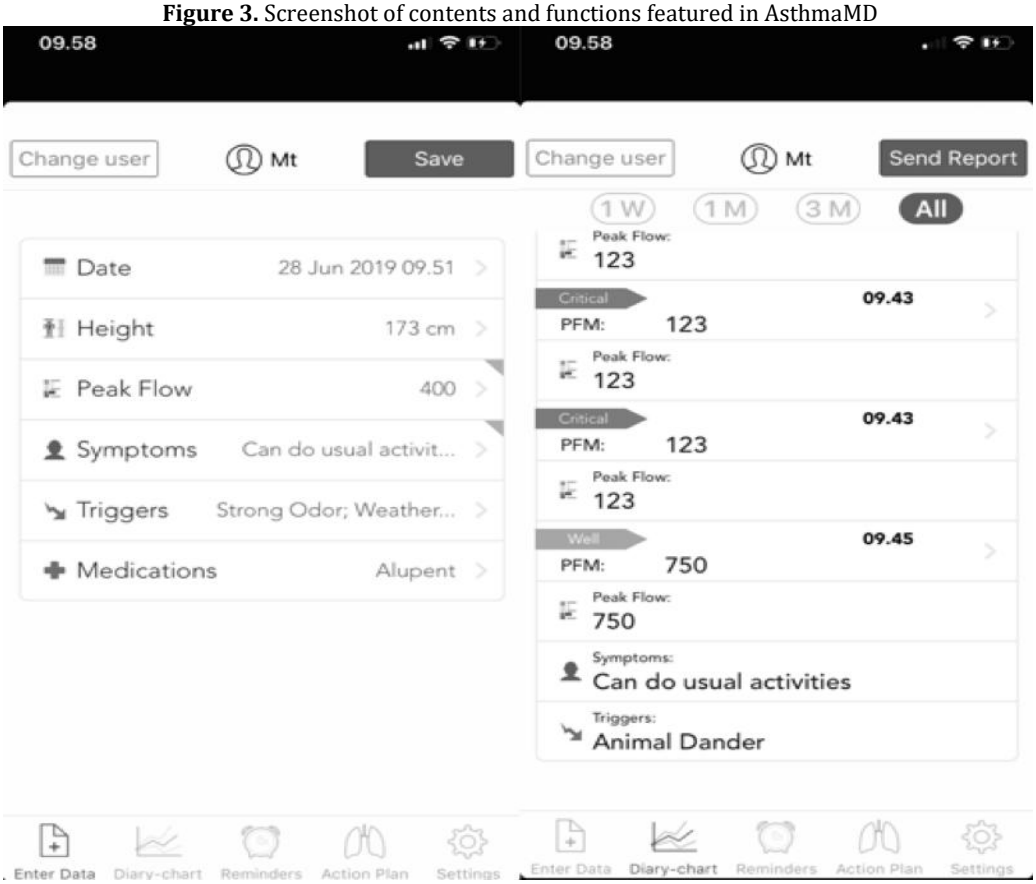
Figure 2. A list of contents of selected asthma self-management apps



DISCUSSION

Modern people use smartphone apps as a support in improving their health as well as guiding health lifestyle. The apps seem to be a promising portable gadget to enhancing asthma self-management; however, evidence related to the role of apps in the self-management is still limited and the use of the apps in improving self-management needs more studies to say for sure. This analytical study used a systematic approach to examine as well as to explore the contents and functions of Google Android OS apps for asthmatics commercially available at Google Playstore website (https://play.google.com/store/apps). It primarily outlines contents and functions featured into a number of Google Android OS based asthma self-management applications commercially available in Indonesian market.

Figure 3. Screenshot of contents and functions featured in AsthmaMD



This study found 25 apps providing educational materials related to disease information. The information may vary but include various topics in asthma, such as asthma overview, signs and symptoms of asthma, diagnosis, and treatment. A good asthma education should provide information as stated on the guidelines for the diagnosis

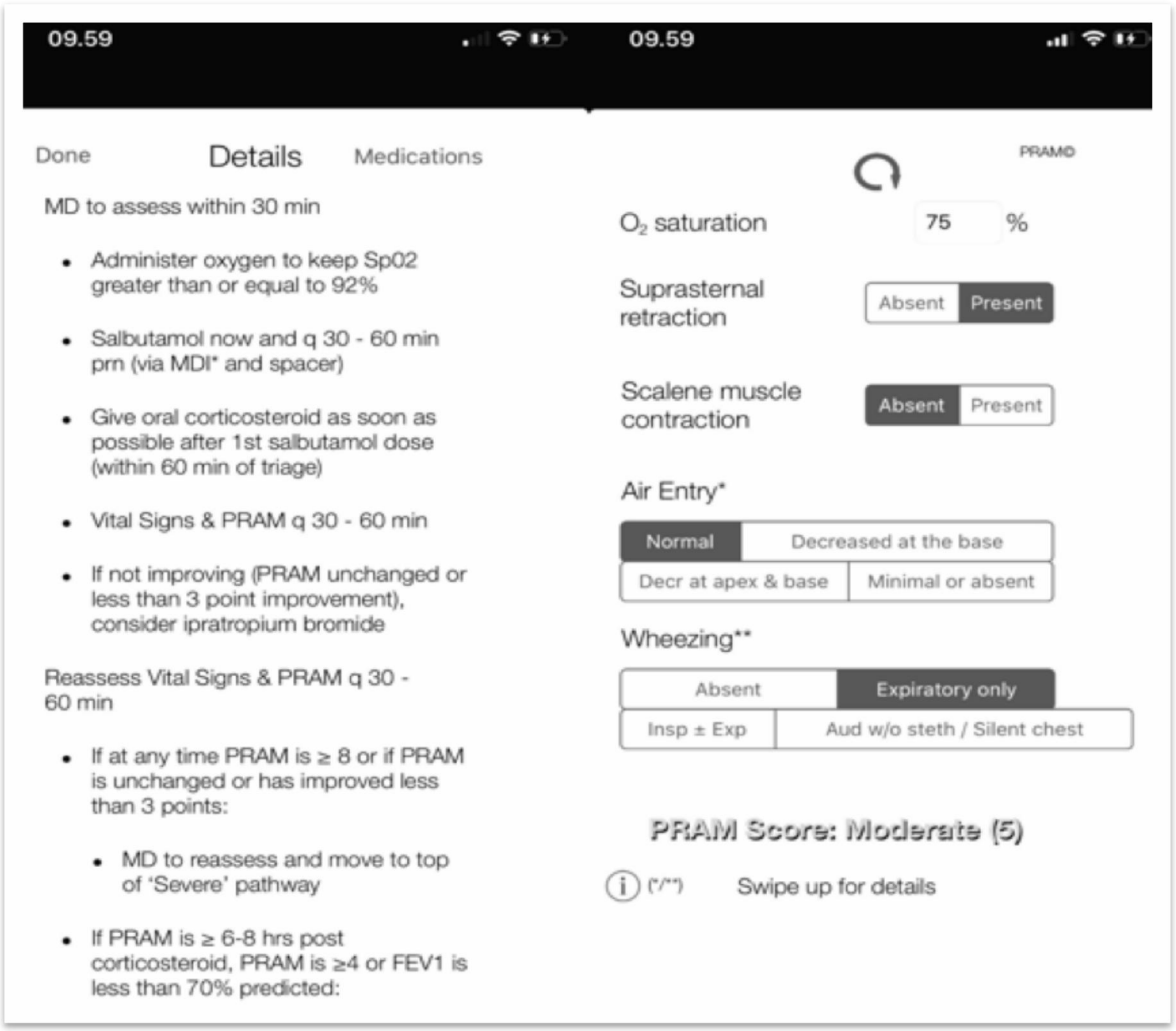
and management of asthma officially issued by The National Asthma Education and Prevention Program[15]. A detail component of asthma education is shown on the Table 3 below.

Table 3. A list of a component of asthma education

A Component of Asthma Education
Teach and reinforce at every opportunity: • Basic facts about asthma. • What defines well-controlled asthma and the patient's current level of control. • Roles of medications. • Skills (i.e. inhaler technique, use of a valved holding chamber or spacer, self-monitoring). • When and how to handle signs and symptoms of worsening asthma. • When and where to seek care. • Measures to prevent or limit exposure to asthma triggers.

Many apps explored asthma education in depth, but most selected apps seem to fail in providing complete coverage of many of the professional or evidence-based statements coming from standardized international guidelines. It means that most selected apps were not sufficient as portable education devices for asthmatics. It was due to educational materials that did not involve medical professionals when developing the apps. In this study, we found 67% (n=16) educational asthma apps explaining about asthma remedies with several alternative options such as breathing exercises, home remedies, Indian yoga exercises, and other complementary options. In designing and developing process of asthma apps, involving professionals such as doctors, pharmacists, nurses, etc., is very important. It aims to help ensure that the apps include relevant and evidence-based information for patients. A lack of evidence does not only disrupt the safety and quality of apps but also increase risks to patients[16]. The contents of apps that are peer-reviewed, evidence based, and providing up-to-date clinical information seem to be one of potential solutions to quality assurance, but unfortunately, its feasibility needs more study to say for sure[17]. It is quite essential to ensure that the apps do not disrupt the patient safety, notably if recommended by a medical professional.

Figure 4. Screenshot of contents and functions found in PRAM



Unused asthma apps, regardless of the involvement of health professionals, adherence to evidence, as well as app regulation, are likely ineffective. The most essential thing is to balance the safety and quality app requirements with design features for promoting adherence to therapy. The behavioral change models in emerging eHealth literature described that a number of factors including perceived usefulness, perceived risk of

use, and also degree of user-centric focus, influenced the uptake and usage of information and communication technology. In the development of asthma apps as a potential portable medical device, in addition to the adherence of users, the quality and safety of the apps are essential. This is why developing the apps in the future must strongly concern on the theory of behavioral changes and considerations regarding to the predictions of usage and user-centric approaches. A framework development built for internet-based formats seems possible to be applied to the smartphone apps[18].

Educational contents in the asthma apps are also essential regarding to the improvement of adherence and behavioral changes. An ideal asthma education should provide information standardized by The National Asthma Education and Prevention Program. It should have at least information as follows: (a) basic facts about asthma, (b) conditions that define well-controlled asthma, (c) proper medications, (d) patient's skill in using asthma devices such as inhaler and spacer, (e) ways to make worsening asthma symptoms under control, (f) how to seek professional care, and (g) ways to prevent or limit exposure to potential asthma triggers.

This study examined a number of contents and functions featured in the Google Android asthma apps that may be beneficial for asthmatics in improving self-management as well as health outcomes. Asthma education is very crucial in the asthma self-management. Poor education was associated with unnecessary and frequent visits to the Emergency Department for asthma care. These points also suggested inefficient application of management action plan[19]. Educational materials related to asthma-self management, involving information, medical review, self-monitoring, and a written asthma action plan, is very effective in improving quality of life as well as reducing unnecessary visits in Emergency Room, doctors, specialists, days lost from work, and also episodes of nocturnal asthma[20]. An ideal asthma app should provide evidence-based educations that meets the needs of users.

In this study, it was found 9 apps that basically feature beneficial contents and functions, such as: a personal asthma diary, list of asthma medications, tracker of medication action, peak flow meter mapper, asthma zone calculator, asthma control questionnaires, asthma action plan, chat with professionals, etc. A study published in 2016 found an improvement on Asthma Control Test scores from 16.6 (inadequate to poor controlled) to 20.5 (controlled) in asthmatics, with a mean age of 50 years, over the period of study. The study also stated that smartphone apps provide a cost-effective, easily scalable, and efficacious way to improve self-management as well as health outcomes in asthmatics. On the other hand, a review published in 2017 has found that the potential of asthma apps for improving asthma self-management varies considerably between apps. Therefore, the review suggested that health professionals and patients with asthma should carefully read the app reviews before recommending or using the apps[21].

A personalized asthma diary can help asthmatics in recording peak expiratory flow readings and asthma symptoms, comparing the peak expiratory flow readings with asthma zones, and keeping medication use in a case of sudden asthma attack. It helps asthmatics in monitoring asthma triggers as well as asthma medications. Keeping an asthma diary can help patients recognize asthma attacks and prevent them from getting worse. Additionally, an asthma diary also helps general practitioners or specialists in evaluating asthma action plan[22]. An asthma action plan, also known as a management plan, describes a written action plan that patients create with a general practitioner or specialist in order to help control asthma complaints. In addition to warning signs and symptoms, a written asthma action plan also educates patients on how to use a peak flow meter regularly as well as to realize what to do in a breathing emergency[23]. It might be one of reasons why Guidelines by Global Initiative for Asthma (GINA) recommend doctors and specialists to provide a written asthma action plan to patients with asthma[24]. In a study, it is suggested an association between the use of the smartphone-based asthma action plan and potentially clinically relevant improvements in Asthma Control Test score over time compared with use of a paper-based action plan.

Another useful feature found in the reviewed asthma self-management apps is peak flow meter mapper. Some evidences suggest that peak flow readings can provide asthmatics and health care professionals with information regarding to changes in pulmonary obstruction. Peak flow readings, according to some evidences, can influence perceptions and responses of patients to asthma symptoms. The peak flow readings are also useful for doctors, pharmacists. and health care professionals in documenting potential asthma triggers, assessing responses of therapeutic interventions, as well as facilitating the tailoring of therapy[25]. Less popular contents and functions in the reviewed asthma self-management apps include asthma symptom monitor, asthma quiz, social media, lung function monitor, and chat with health professionals. A better asthma control can be achieved by avoiding all potential triggers, developing patient adherence regarding to the controller medication, and improving patient's ability in recognizing and responding asthma symptoms. It is why asthma symptom and lung function monitor should be featured in the asthma self-management app. Another function, namely chat with health professionals, was found in an asthma self-management app. Similar with social media feature, a chat function is beneficial for building communication between asthmatics with health care professionals. An interactive function, namely asthma quiz, was also found in one reviewed app. Quiz-based games designed for asthma education help improve knowledge in asthmatics, although there was little or no change in behaviors and clinical outcomes[26].

There are a number of asthma self-management apps available at the Google Playstore. Many of the apps performed consistently, thus potentially improving self-management. The pros of asthma self-management apps commercially available at Google Playstore include: (a) some apps have standardized educational materials; and (b) essential functions such as: asthma action plan, asthma control test, peak flow meter, symptom monitors, etc. are easy to use and available just in one app, so potential users do not need to install more app. Unfortunately, the cons of the apps were most of them have low quality and did not involve medical professionals when designing and developing the apps. It is a reason why potential users, both asthmatics and health care professionals, should consider app reviews as a decision support tool before deciding or recommending an asthma app. Both designing and developing a complete asthma app may mark the essential steps in propagating self-management. The apps potentially develop the self-

initiation of asthma management by first measuring symptoms of asthma using a symptom diary function and providing appropriate subsequent management advice. Additionally, the apps also provide advices about the treatment as well as improve the asthma control. However, more studies with large population are needed to supply more reliable evidence for their use in clinical practice.

Limitations

The primary limitation of this analytical study included the assessment method was developed by the authors and the method has not been validated. Additionally, this study was also limited to free apps, using English language, above four stars rating, and based on Google Android Operating System. The authors, despite the limitations of this study, believe that the study provided information related to what contents and functions should be featured in an ideal asthma self-management app.

CONCLUSION

Smartphone apps may provide a beneficial support regarding to the self-management education and monitoring of asthmatics. Unfortunately, in addition to professional medical involvement, most contents and functions featured in the apps are also lack of clinical study validation and adherence to international guidelines. An ideal asthma self-management app should minimally feature contents and functions, such as easy-to-understand knowledge about pathophysiology and treatment of asthma, list of asthma medication, asthma control test, asthma action plan, and asthma diary that records about medication usage, symptoms, peak flow readings, etc.

Ethical Considerations

Any ethical issues, including plagiarism, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

Acknowledgement

This analytical study is financially supported by Domestic Postgraduate Education Scholarship by Ministry of Research, Technology, and Higher Education of the Republic of Indonesia, number: T/403/D.D3/KH.04.00/2019.

Conflict of Interest

The authors declare that there are no conflicts of interests.

REFERENCES

1. Karamaoun C, Van Muylem A, Haut B. Modeling of the Nitric Oxide Transport in the Human Lungs. Front Physiol [Internet]. 2016 [cited 2020 Jun 7];7. Available from: https://www.frontiersin.org/articles/10.3389/fphys.2016.00255/full
2. Ali NS, Nanji K. A review on the role of vitamin D in asthma. Cureus. 2017;9(5).
3. Zamora F, Cho R, Rao M, Gibson H, Dincer HE. Endobronchial thermoplasty for asthma. J Vis Surg [Internet]. 2017 Sep 14 [cited 2020 Jun 7];3. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5639038/
4. Sheehan WJ, Permaul P, Petty CR, Coull BA, Baxi SN, Gaffin JM, et al. Association Between Allergen Exposure in Inner-City Schools and Asthma Morbidity Among Students. JAMA Pediatr. 2017 Jan 1;171(1):31–8.
5. Hatta M, Surachmanto EE, Islam AA, Wahid S. Expression of mRNA IL-17F and sIL-17F in atopic asthma patients. BMC Res Notes. 2017 Jun 12;10(1):202.
6. Burgel P-R, Contoli M, López-Campos JL. Acute Exacerbations of Pulmonary Diseases. European Respiratory Society; 2017. 276 p.
7. Himes BE, Weitzman ER. Innovations in health information technologies for chronic pulmonary diseases. Respiratory Research. 2016 Apr 5;17(1):38.
8. Jaramillo Y, Reznik M. Do United States' Teachers Know and Adhere to the National Guidelines on Asthma Management in the Classroom? A Systematic Review [Internet]. Vol. 2015, The Scientific World Journal. Hindawi; 2015 [cited 2020 Jun 7]. p. e624828. Available from: https://www.hindawi.com/journals/tswj/2015/624828/
9. Ventola CL. Mobile Devices and Apps for Health Care Professionals: Uses and Benefits. P T. 2014 May;39(5):356–64.
10. Lin J, Amini S, Hong JI, Sadeh N, Lindqvist J, Zhang J. Expectation and purpose: understanding users' mental models of mobile app privacy through crowdsourcing. In: Proceedings of the 2012 ACM Conference on Ubiquitous Computing [Internet]. Pittsburgh, Pennsylvania: Association for Computing Machinery; 2012 [cited 2020 Jun 6]. p. 501–510. (UbiComp '12). Available from: https://doi.org/10.1145/2370216.2370290
11. KURTI AN, DALLERY J. INTEGRATING TECHNOLOGICAL ADVANCEMENTS IN BEHAVIORAL INTERVENTIONS TO PROMOTE HEALTH: UNPRECEDENTED OPORTUNITIES FOR BEHAVIOR ANALYSTS. Rev Mex Anal Conducta. 2014 Sep;40(2):106–26.
12. Pinnock H, Parke HL, Panagioti M, Daines L, Pearce G, Epiphaniou E, et al. Systematic meta-review of supported self-management for asthma: a healthcare perspective. BMC Medicine. 2017 Mar 17;15(1):64.
13. Morrow S, Daines L, Wiener-Ogilvie S, Steed L, McKee L, Caress A-L, et al. Exploring the perspectives of clinical professionals and support staff on implementing supported self-management for asthma in UK general practice: an IMP 2 ART qualitative study. npj Primary Care Respiratory Medicine. 2017 Jul 18;27(1):1–7.
14. Tinschert P, Jakob R, Barata F, Kramer J-N, Kowatsch T. The Potential of Mobile Apps for Improving Asthma Self-Management: A Review of Publicly Available and Well-Adopted Asthma Apps. JMIR mHealth and uHealth. 2017;5(8):e113.
15. Asthma Care Quick Reference: Diagnosing and Managing Asthma. :12.
16. Buijink AWG, Visser BJ, Marshall L. Medical apps for smartphones: lack of evidence undermines quality and safety. Evid Based Med. 2013 Jun;18(3):90–2.

17. Visser BJ, Buijink AWG. Need to peer-review medical applications for smart phones. J Telemed Telecare. 2012 Mar;18(2):124.
18. Hilgart MM, Ritterband LM, Thorndike FP, Kinzie MB. Using Instructional Design Process to Improve Design and Development of Internet Interventions. J Med Internet Res [Internet]. 2012 Jun 28 [cited 2020 Jun 7];14(3). Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3414906/
19. Al-Muhsen S, Horanieh N, Dulgom S, Assiri Z, Vazquez-Tello A, Halwani R, et al. Poor asthma education and medication compliance are associated with increased emergency department visits by asthmatic children. Annals of Thoracic Medicine. 2015 Apr 1;10(2):123.
20. Gibson PG, Ram FSF, Powell H. Asthma education. Respir Med. 2003 Sep;97(9):1036–44.
21. Tinschert P, Jakob R, Barata F, Kramer J-N, Kowatsch T. The Potential of Mobile Apps for Improving Asthma Self-Management: A Review of Publicly Available and Well-Adopted Asthma Apps. JMIR Mhealth Uhealth. 2017 Aug 2;5(8):e113.
22. Perry TT, Marshall A, Berlinski A, Rettiganti M, Brown RH, Randle SM, et al. Smartphone-based vs paper-based asthma action plans for adolescents. Annals of Allergy, Asthma & Immunology. 2017;118(3):298–303.
23. Arekapudi KL, Norris C, Updegrove S. Improving Self-Efficacy of Student Asthma Management in Elementary and Preschool Staff. The Journal of School Nursing. 2020;1059840520904760.
24. Ehrich S. Improving Adolescent Asthma Management Using a Smart Phone Application [PhD Thesis]. University of Missouri–Kansas City; 2020.
25. Cross D, Nelson HS. The role of the peak flow meter in the diagnosis and management of asthma. Journal of Allergy and Clinical Immunology. 1991 Jan 1;87(1, Part 1):120–8.
26. Drummond D, Monnier D, Tesnière A, Hadchouel A. A systematic review of serious games in asthma education. Pediatr Allergy Immunol. 2017;28(3):257–65.