HHS Public Access

Author manuscript

J Allergy Clin Immunol Pract. Author manuscript; available in PMC 2020 November 01.

Published in final edited form as:

J Allergy Clin Immunol Pract. 2019 ; 7(8): 2583–2591. doi:10.1016/j.jaip.2019.03.041.

A Systematic Evaluation of Asthma Management Apps Examining Behavior Change Techniques

Rachelle R. Ramsey, PhD[a,b], **Julia K. Caromody, PhD**[a], **Sara E. Voorhees, MS**[c], **Amanda Warning, MA**[a], **Christopher C. Cushing, PhD**[d], **Theresa W. Guilbert, MD, MS**[b,e], **Kevin A. Hommel, PhD**[a,b], **David A. Fedele, PhD**[c]

[a]Division of Behavioral Medicine and Clinical Psychology, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio

[b]Department of Pediatrics, University of Cincinnati College of Medicine, Cincinnati, Ohio

[c]Department of Clinical & Health Psychology, University of Florida, Gainesville, Fla

[d]Clinical Child Psychology Program and Schiefelbusch Institute for Life Span Studies, University of Kansas, Lawrence, Kan

[e]Division of Pulmonary Medicine, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio

Abstract

BACKGROUND: Mobile health (mHealth) apps have the potential to facilitate asthma self-management by including medication reminders, allowing self-monitoring of symptoms, improving access and quality of information communicated with provider, and providing educational resources to patients and parents. Many apps exist for asthma management; however, the extent to which apps include evidence-based behavior change strategies has not been examined.

OBJECTIVE: To review the content and quality of mHealth asthma management apps that are available to patients. METHODS: Asthma apps were identified using a systematic search process. Twenty-three apps were coded for presence or absence of behavior change techniques (BCTs) using the taxonomy of BCTs as defined by Abraham and Michie in 2008. Quality ratings were also determined for each app using the Mobile App Rating Scale (MARS).

RESULTS: The number of BCTs each app used ranged from 1 to 11 (mean, 4). BCTs that were most commonly used were instruction, behavior-health link, self-monitoring, feedback, teach to use prompts/cues, consequences, and others' approval. Overall app quality based on MARS scores ranged from 2.45 to 4.50 (mean, 3.32). Two apps, Kiss myAsthma and AsthmaMD, used at least 8 BCTs and had high quality ratings.

CONCLUSIONS: Kiss myAsthma and AsthmaMD used at least 8 BCTs and had good quality scores.

Corresponding author: Rachelle R. Ramsey, PhD, Cincinnati Children' s Hospital Medical Center, Division of Behavioral Medicine and Clinical Psychology, 3333 Burnet Ave, MLC: 7035, Cincinnati, OH 45229. rachelle.ramsey@cchmc.org.

Conflicts of interest: The authors declare that they have no relevant conflicts of interest.

Keywords

Asthma; Self-management; Apps; mHealth

INTRODUCTION

More than 24 million people in the United States are diagnosed with asthma.[1] Effective asthma management entails taking medications as prescribed, self-monitoring symptoms, adhering to a personalized asthma action plan, identifying and minimizing exposures to environmental triggers, attending medical appointments, and communicating with providers about symptoms and treatments.[2] Clinic visits serve as the primary setting for patients to receive asthma education and self-management support; however, patients are increasingly looking to mobile apps for information and assistance with self-management.[3] Apps have the potential to support self-management by (1) addressing barriers to self-management, such as offering medication reminders to target forgetting, (2) enabling real-time self-monitoring of symptoms, (3) facilitating information sharing between patients, caregivers, and clinicians, and (4) providing educational content and resources.

For patients with asthma, their caregivers, and providers, there is little guidance on how to identify high-quality, user-friendly, and evidence-based apps to support asthma management from the hundreds of existing asthma-focused apps on the iOS or Android platforms.[3,4] In 2015, Wu et al[3] provided a review of available asthma-related apps with regard to functionality and issued a call for further assessment of quality in asthma-related apps. To our knowledge, only one systematic review has investigated the quality of asthma apps. Huckvale et al[4] found that 40% of apps recommended acute asthma management strategies that were not evidence-based and only 25% of apps offered information (eg, managing exacerbations and inhaler technique) consistent with international medical guidelines. Although this review highlights concerns with the informational content, little is understood about the extent to which asthma apps incorporate effective behavior change strategies supported by the health promotion literature.

Evidence-based health promotion interventions incorporate a range of behavioral techniques to affect behavior change. The taxonomy of behavior change techniques (BCTs) is a coding system to reliably identify operationalized, theory-linked BCTs used in interventions[5] such as goal-setting, self-monitoring, instructions, others' approval, identifying barriers, and providing feedback on performance. The taxonomy has been widely used to evaluate components of health behavior interventions, including interventions delivered via mobile platforms.[6-8] Recent systematic reviews of technology-based chronic illness self-management interventions indicate that the inclusion of multiple BCTs is associated with increased intervention effectiveness.[9] Moreover, within asthma, the most effective self-management interventions incorporate a combination of BCTs, most commonly self-monitoring, providing feedback, goal-setting, barrier identification, and providing reinforcement.[10,11] Thus, as patients and providers are increasingly turning to health technology to support self-management, there is a critical need to understand the extent to which evidence-based behavior change components have been translated to asthma apps.

Our first aim was to systematically evaluate the content of free, publicly available asthma apps using the taxonomy of BCTs. By characterizing existing asthma apps for the presence or absence of BCTs, we sought to (1) detail the extent to which traditional evidence-based BCTs are translated in mobile apps, (2) provide a method for comparing apps with similar content and functions, and (3) gain an understanding of which apps may be considered by providers and patients based on inclusion of BCTs. In addition to the inclusion of evidence-based BCTs, the potential for any app to improve health behaviors depends on its usability, meaning the quality of engagement, functionality, aesthetics, and information.[12] Therefore, the second aim of this study was to evaluate the quality of commercially available asthma apps using a validated expert rating scale.

METHOD

BCT coding manual adaptation and training

We adapted Abraham and Michie's[5] coding manual to code the presence of BCTs in our sample of mHealth apps. Abraham and Michie define BCTs identified from theoretical behavior change frameworks such as the information-motivation-behavioral skills model, social-cognitive theory, and theory of planned behavior. All 26 of the theoretically identified BCTs from Abraham and Michie were included in our manual. Examples of BCTs include providing information about behavior-health link, identifying barriers to performing health behaviors, and prompting self-monitoring of behaviors. See Table I for BCT definitions and examples of BCTs used in apps. Senior authors with experience coding BCTs (C.C.C., D.A.F., and R.R.R.) used the BCT coding system to actively code 5 health-related apps, reach consensus, and develop training sessions for raters.

Three raters received approximately 6 hours of training on the adapted Abraham and Michie coding manual. Raters were advanced psychology doctoral trainees with an underlying understanding of BCTs. Training consisted of reviewing BCTs to understand and clarify distinctions between techniques. Next, raters practiced coding 2 commonly used mHealth apps. To code apps, raters first read and coded the entire description of the app from the Apple or Google Play app store. In cases in which apps were available on both platforms, one platform was selected and used by all raters. Next, raters downloaded and interacted with the app for a minimum of 10 minutes, coding all 26 techniques for either presence or absence. Each app technique was coded as present if the technique matched the description from the BCT coding manual. Raters then met with senior study authors to discuss discrepancies and reach consensus on presence or absence of the BCTs for each app. Next, raters independently coded 5 asthma apps following the same procedure (Asthma MD, Asthma Logger, Asthma [Health Care IT], Home Remedy for Asthma [StatesApps], and Home Remedies for Asthma [Rockerz Group]). These apps were identified for training because they were the top 5 apps listed in the app and/or Google Play store.

Identification of mHealth apps for asthma

mHealth apps for asthma management were identified through 4 systematic searches. First, the term "asthma" was searched in the Apple app store and the Google Play store. A list of the first 25 apps for each of these searches was recorded, because it was estimated that a

typical consumer would consider at most the first 25 results when selecting an app.[13] Next, "asthma management" was searched on each device and the first 25 apps were recorded. Apps were excluded if they were not specifically related to asthma, had an associated cost (were not free), or were not patient-facing. One master list was then created, excluding any duplicate apps from the searches.

Using BCTs and MARS to code asthma apps

The final list of asthma apps was divided among 3 raters, and each app was coded independently for the presence or absence of BCTs. Quality ratings were also determined for each app using the MARS.[12] The MARS is a 23-item measure used to assess the quality of mHealth apps on 5 domain areas: engagement, functionality, aesthetics, information quality, and subjective quality. Each domain has between 3 and 7 questions that are rated on a 5-point scale from 1 (Inadequate) to 5 (Excellent). Item responses within each domain were averaged to obtain engagement, functionality, aesthetics, information quality, and subjective quality scores. An overall quality score was calculated for each app by averaging the engagement, functionality, aesthetics, and information quality subscale scores.

Interrater reliability strategy

At least 20% of the remaining apps were randomly selected to be double coded using the BCT manual (n = 5) and the MARS (n = 6) to assess reliability of the coding system and agreement between raters. Percent agreement was calculated to assess agreement between each of the 2 raters on all the 26 BCTs for the 5 apps that were double coded. Intraclass correlation coefficients were calculated to assess agreement between raters on the 6 mean MARS scores from the apps that were double coded.

RESULTS

Initial searches revealed 95 apps related to "asthma" and "asthma management." From the original 95 apps, we removed 55 apps on the basis of title and description of the app for the following reasons: 26 were duplicates, 3 were non-English, 18 were not specific to asthma, 6 could not be downloaded for free, and 2 required an external device (ie, electronic medication tracker). Of the 40 apps that were downloaded and screened, 17 apps were removed for the following reasons: 8 could not be downloaded, 3 were not patient-facing, 1 was a non-English app, and 1 led to an external website. In addition, 4 apps were duplicates that were not previously screened out because of slight variations in the app titles. This resulted in 23 asthma-related apps to be reviewed (see Table II for complete list and brief descriptions of each app).

The 23 apps ranged in use of BCTs from 1 BCT to 11 BCTs (mean, 4 BCTs). The most commonly included BCTs in asthma management apps are instruction, behavior-health link, self-monitoring, feedback, teach to use prompts/cues, consequences, and others' approval (see Table I for further descriptions and examples of BCTs). "Instruction" on asthma-related behaviors, used in 65% (n = 15) of the apps, was used to tell patients how to perform asthma-related behaviors (eg, the best way to know when you need a refill is to count the number of puffs given). Teaching on the "behavior-health link" provided information about

the relationship between a behavior and health (eg, using preventative, long-term control medications to reduce the inflammation in your airways that leads to symptoms) and was used in 52% (n = 12) of apps. Similarly, “self-monitoring” of a specified asthma symptom or behavior enabled users in 52% (n = 12) of the apps to track asthma symptoms and/or medication use and “provided feedback” to the user about the specified asthma symptom and/or behavior that was being monitored (eg, chart showing frequency of rescue inhaler use in last 7 days) (n = 12). “Teach to use prompts/cues” provided teaching on how to use environmental prompts to remind users to perform a behavior (eg, push notifications or calendar reminders to take medication) and was used in 39% (n = 9) of the apps. “Consequences” provided information regarding the positive and negative results that might happen when an asthma behavior is performed/not performed and was present in 39% (n = 9) of apps. Finally, “others’ approval” including the information about what others might think about the patient’s target asthma behavior and/or the ability to share behavior/disease information with others (eg, physician) was found in 26% (n = 6) of apps. Specifically, 6 of the reviewed apps included the option for users to share their symptom logs or medication use data with medical providers electronically, allowing users to solicit feedback from providers on their health behaviors and progress while 3 apps allowed users to send asthma control test scores or peak flow meter reports to providers via email.

Three apps (ie, AsthmaMD, Kiss myAsthma, and My Breathefree) used at least 8 BCTs. These 3 apps each used behavior-health link, consequences, others’ approval, instruction, self-monitoring, feedback, and teach prompts. Kiss myAsthma also used prompt intention formation, a review of behavior goals, and stress management, whereas AsthmaMD and MyBreathe-Free used modeling. Seven apps (Asthma Action Hero, Asthma Guide [Nicholas Gabriel], Asthma Health Storylines, Asthma Monitor, Home Remedies for Asthma [Rockerz Group], Asthma Test, and SaniQ Asthma) used between 4 and 6 BCTs, and 13 apps used fewer than 4 BCTs. Table III provides a list of BCTs included in each of the 23 apps.

With regards to app quality, the overall quality of the apps ranged from 2.45 to 4.50 (of a possible 5) and the average overall quality score across all apps was 3.32 (0.64). Average subscale scores ranged from 2.68 (0.95) for engagement to 4.08 (0.53) for functionality.

Four apps had an overall MARS quality of more than 4.0 (AsthmaMD, Asthma Health Storylines, Kiss myAsthma, and Wizdy Pets: Kids’ Asthma Game), and 5 apps (Asthma Action Hero, ASTHMA: Management, Asthma Tracker, My Breathefree, and SaniQ Asthma) had overall MARS quality scores between 3.5 and 4.0. The MARS subscale and overall app quality scores for each app can be found in Table IV.

Percent agreement was 100% for most of BCT classifications. Percent agreement for general encouragement and instruction was 80%, and consequences, other’s approval, and stress management had 60% agreement. Intraclass correlation coefficients were all excellent: MARS A (engagement subscale) = .94, MARS B (functionality subscale) = .91, MARS C (aesthetics) = .98, MARS D (information subscale) = .90, MARS overall app quality subscale = .98, and MARS app subjective quality = .95. These intraclass correlation coefficients were consistent with previous literature.[12]

DISCUSSION

This study fills a gap in the literature by reviewing the asthma apps available to patients to allow physicians and health care professionals to make self-management app recommendations on the basis of quality and evidenced-based BCTs used. We found 23 asthma-related apps that are free and publicly available to patients via the Apple or Google Play stores. The apps ranged from 1 to 11 in use of BCTs (mean, 4) and in overall app quality from 2.43 to 4.5 (mean, 3.32). Commonly used BCTs within the asthma-related apps fall into 2 broad categories: education and behavioral strategies. These broad categories are consistent with previous review findings.[3]

Providing information on the behavior-health link, consequences, and instructions can each be categorized as educational strategies. Traditional asthma self-management interventions often include an educational component to help patients understand the most important aspects of asthma self-management (behavior-health link), learn how engaging in self-management behaviors can impact their health (consequences), and acquire the necessary skills for managing their asthma, such as proper inhaler technique and following personal asthma action plans (instruction). Although this knowledge is a critical component of effective self-management, education alone is most often insufficient to improve asthma control and adherence to treatment.[14,15]

Patient self-monitoring is a key behavioral aspect of asthma management and is advocated by current standard of care guidelines.[2,16] In traditional asthma self-management interventions, systematic monitoring is associated with improvements in lung function and increased awareness of symptomatology.[15,17] Similarly, medication self-monitoring is associated with increased adherence to inhaled corticosteroid therapy and improved asthma outcomes in children and adults, particularly when paired with adherence feedback.[18-20] Interventions that combine educational components with additional behavioral strategies, such as self-monitoring, show improved medication adherence, better symptom control, and reduced emergency department visits compared with education alone[15,21] or self-monitoring alone.[22] Therefore, although the individual self-management needs and preferences of patients should be considered when helping patients choose an app, apps that include a combination of educational components and self-monitoring functionality should be recommended.

Other common behavioral strategy BCTs include setting prompts and others' approval. Setting prompts can include alarms to remember to take medications, attend appointments, and/or monitor symptoms. This technique has been incorporated and tested in self-management interventions for patients with asthma and the use of medication reminders has been shown to improve adherence.[23,24] One implicit advantage of using mobile apps to support self-management is that apps can provide real-time intervention by prompting users to engage in health behaviors (eg, taking medication and monitoring symptoms). Therefore, providers should consider recommending apps with reminder functionality. Others' approval or the ability to share app data with medical providers was also a consistent strategy used in the apps. Interestingly, none of the reviewed apps allowed for real-time communication between patients and providers nor did they allow providers to access app data directly (eg,

via a clinician dashboard) without a patient-initiated email. Increased exchange of patient data with medical teams serves to facilitate patient-provider communication, enhance treatment planning, and improve asthma outcomes.[25] Again, depending on the specific self-management needs of the patient, apps that facilitate data sharing may be most beneficial to both patients and providers.

Providers acknowledge that there is a need for improved self-management skills in patients with uncontrolled asthma and are increasingly making recommendations for mobile app—assisted care.[16] On the basis of the existing literature related to traditional interventions and this review of asthma management apps, when making recommendations, providers should look for apps that include the identified core BCTs (behavior-health link, consequences, instruction, self-monitoring, feedback, teach to use prompts/cues, and others' approval). The purpose of this study was to review the content of asthma management apps with regard to the use of BCTs and app quality. Although formal efficacy testing is needed to draw definitive conclusions regarding the efficacy of apps, Kiss myAsthma and AsthmaMD contained the most BCTs and highest usability ratings. This suggests that these apps are likely to be engaging and contain a number of helpful behavioral techniques that have been shown to improve adherence in previous research.

Given the promise of mHealth apps to improve health outcomes in a myriad of ways including helping patients actively measure, monitor, and manage their health condition, it is important that providers have systematic and informed ways of recommending apps to patients. A recent review[26] set out to examine the "prescribability" of mHealth apps. Prescribability is influenced by the current availability of the app, its proven efficacy, and its ability to stand alone; however, paucity of low risk-of-bias randomized controlled trials (RCTs) greatly limits the true prescribability of health apps. Although we agree that evidence of efficacy based on RCTs is the most stringent test of mHealth apps, reviewing the evidence-based BCTs included within mHealth apps can aid physicians in making mHealth recommendations while large-scale mHealth app RCTs are being conducted. Reviewing mHealth apps has become such a priority that the National Health Service (NHS) Apps library recently used an app (AppScript) to make app prescribing even easier for providers. In general, the use of this national app library can inform app prescribability; however, it may not be beneficial for selecting asthma-specific apps because only 3 apps are reviewed: AsthmaMD (included in our review), Wizdy Pets: Kids' Asthma Game (included in our review), and Asthma Journal Free/Pro. One additional app was found in the NHS library (Asthma Tracker & Log Free) when specifically searching by app name. Initiation of this library signifies the need for reviews of apps to be available to providers. Our review of asthma management apps goes beyond the NHS review and previous reviews[3] by reviewing evidence-based BCTs within 23 asthma apps to demonstrate the BCTs and quality of each asthma management app.

This study has several limitations. First, app store results are based on popularity; therefore, the top apps generated from each search did not necessarily reflect the highest quality apps. This procedure for identifying apps was chosen on the basis of consumer app search and selection behaviors.[13] Second, apps were not used for extended time periods, meaning identified BCTs and quality ratings were based on one-time use. Therefore, it is possible that

certain features (eg, user earns reinforcement for taking medications every day of the week) may not have been apparent to reviewers during the trial period. Third, the percent agreement between raters was low for 3 of the BCTs; however, for the other 23 BCTs, percent agreement was good to excellent. Finally, it is important to note that no studies have documented the most important mHealth BCTs and the apps reviewed have not been tested in RCTs. As such, recommendations are not based on app effectiveness to improve self-management. Studies evaluating app effectiveness and the effectiveness of specific mHealth BCTs for patients with asthma are a crucial next step.

Currently, anyone can create and publish health and medical apps without having to use evidence-based strategies or testing them, making it difficult for providers to recommend mHealth apps to improve self-management. This review of available asthma management apps examined the BCTs used within each app to improve self-management and can be used as an initial guide for making recommendations. It is clear that a significant number of patients are using mHealth apps to help with disease management and that the number of patients interested in mHealth tools is growing.[27] Therefore, it is important that providers strive to become more familiar with which apps their patients are using and how they can best use information obtained from apps to improve patient care. Providers are encouraged to use national app libraries such as the NHS Apps library and scholarly review articles to recommend apps to their patients. Based on the results of this review, optimal asthma management apps include the following BCTs: behavior-health link, consequences, instruction, self-monitoring, feedback, teaching prompts, and other's approval. Currently available apps using these BCTs and high quality ratings are AsthmaMD and Kiss myAsthma. Because of the rapid proliferation of mHealth apps, it will be important to routinely reassess the asthma mHealth ecosystem to provide updated recommendations.

Acknowledgments

This work was supported by a training grant from the National Institutes of Health (grant no. T32HD068223 to J.K.C.).

Abbreviations used

BCT	Behavior change technique
MARS	Mobile App Rating Scale
NHS	National Health Service
RCT	Randomized controlled trial

REFERENCES

1. Centers for Disease Control and Prevention. Asthma morbidity; 2016 Available from: https://www.cdc.gov/nchs/fastats/asthma.htm. Accessed May 16, 2018.
2. National Heart, Lung, and Blood Institute. Asthma Care Quick Reference: Diagnosing and Managing Asthma. Available from: https://www.nhlbi.nih.gov/sites/default/files/publications/12-5075.pdf. Accessed May 16, 2018.

3. Wu AC, Carpenter JF, Himes BE. Mobile health applications for asthma. J Allergy Clin Immunol Pract 2015;3:446. [PubMed: 25725939]
4. Huckvale K, Morrison C, Ouyang J, Ghaghda A, Car J. The evolution of mobile apps for asthma: an updated systematic assessment of content and tools. BMC Med 2015;13:58. [PubMed: 25857569]
5. Abraham C, Michie S. A taxonomy of behavior change techniques used in interventions. Health Psychol 2008;27:379. [PubMed: 18624603]
6. Brannon EE, Cushing CC. A systematic review: is there an app for that? Translational science of pediatric behavior change for physical activity and dietary interventions. J Pediatr Psychol 2014;40:373–84. [PubMed: 25502745]
7. Vollmer Dahlke D, Fair K, Hong YA, Beaudoin CE, Pulczinski J, Ory MG. Apps seeking theories: results of a study on the use of health behavior change theories in cancer survivorship mobile apps. JMIR MHealth UHealth 2015;3:e31. [PubMed: 25830810]
8. Yang C-H, Maher JP, Conroy DE. Implementation of behavior change techniques in mobile applications for physical activity. Am J Prev Med 2015;48:452–5. [PubMed: 25576494]
9. Morrison D, Wyke S, Agur K, Cameron EJ, Docking RI, MacKenzie AM, et al. Digital asthma self-management interventions: a systematic review. J Med Internet Res 2014;16:e51. [PubMed: 24550161]
10. Denford S, Taylor RS, Campbell JL, Greaves CJ. Effective behavior change techniques in asthma self-care interventions: systematic review and meta-regression. Health Psychol 2014;33:577. [PubMed: 23815765]
11. Pai AL, McGrady M. Systematic review and meta-analysis of psychological interventions to promote treatment adherence in children, adolescents, and young adults with chronic illness. J Pediatr Psychol 2014;39:918–31. [PubMed: 24952359]
12. Stoyanov SR, Hides L, Kavanagh DJ, Zelenko O, Tjondronegoro D, Mani M. Mobile app rating scale: a new tool for assessing the quality of health mobile apps. JMIR MHealth UHealth 2015;3:e27. [PubMed: 25760773]
13. Chavez S, Fedele D, Guo Y, Bernier A, Smith M, Warnick J, et al. Mobile apps for the management of diabetes. Diabetes Care 2017;40:e145–6. [PubMed: 28774944]
14. Battersby M, Von Korff M, Schaefer J, Davis C, Ludman E, Greene SM, et al. Twelve evidence-based principles for implementing self-management support in primary care. Jt Comm J Qual Patient Saf 2010;36:561–70. [PubMed: 21222358]
15. Gibson PG, Powell H, Coughlan J, Wilson A, Hensley M, Abramson M, et al. Limited (information only) patient education programs for adults with asthma. Cochrane Database Syst Rev 2002 CD001005–CD. [PubMed: 12076400]
16. Global Initiative for Asthma. Global Strategy for Asthma Management and Prevention; 2018 Available from: https://ginasthma.org/gina-reports/. Accessed May 16, 2018.
17. Guendelman S, Meade K, Benson M, Chen YQ, Samuels S. Improving asthma outcomes and self-management behaviors of inner-city children: a randomized trial of the Health Buddy interactive device and an asthma diary. Arch Pediatr Adolesc Med 2002;156:114–20. [PubMed: 11814370]
18. Burgess SW, Sly PD, Devadason SG. Providing feedback on adherence increases use of preventive medication by asthmatic children. J Asthma 2010;47:198–201. [PubMed: 20170329]
19. Nides MA, Tashkin DP, Simmons MS, Wise RA, Li VC, Rand CS. Improving inhaler adherence in a clinical trial through the use of the nebulizer chronolog. Chest 1993;104:501–7. [PubMed: 8339641]
20. Onyirimba F, Apter A, Reisine S, Litt M, McCusker C, Connors M, et al. Direct clinician-to-patient feedback discussion of inhaled steroid use: its effect on adherence. Ann Allergy Asthma Immunol 2003;90:411–5. [PubMed: 12722963]
21. Wolf F, Guevara JP, Grum CM, Clark NM, Cates CJ. Educational interventions for asthma in children. Cochrane Database Syst Rev 2003:CD000326. [PubMed: 12535395]
22. Janson SL, McGrath KW, Covington JK, Cheng S-C, Boushey HA. Individualized asthma self-management improves medication adherence and markers of asthma control. J Allergy Clin Immunol 2009;123:840–6. [PubMed: 19348923]
23. Chan AH, Stewart AW, Harrison J, Camargo CA Jr, Black PN, Mitchell EA. The effect of an electronic monitoring device with audiovisual reminder function on adherence to inhaled

corticosteroids and school attendance in children with asthma: a randomised controlled trial. Lancet Respir Med 2015;3:210–9. [PubMed: 25617215]

24. Foster JM, Usherwood T, Smith L, Sawyer SM, Xuan W, Rand CS, et al. Inhaler reminders improve adherence with controller treatment in primary care patients with asthma. J Allergy Clin Immunol 2014;134:1260–1268.e3. [PubMed: 25062783]
25. Wechsler ME. Managing asthma in primary care: putting new guideline recommendations into context. Mayo Clin Proc 2009;84:707–17. [PubMed: 19648388]
26. Byambasuren O, Sanders S, Beller E, Glasziou P. Prescribable mHealth apps identified from an overview of systematic reviews. npj Dig Med 2018;1:12.
27. Digital health consumer adoption: 2015; 2018 Available from: https://rockhealth.com/reports/digital-health-consumer-adoption-2015/#methodology. Accessed May 16, 2018.

What is already known about this topic?

Mobile health apps have the potential to facilitate asthma self-management. Providers acknowledge that there is a need for improved self-management skills in patients with asthma and are increasingly making recommendations for mobile app—assisted care.

What does this article add to our knowledge?

This study fills a gap in the literature by evaluating the evidence-based behavior change techniques and quality of available asthma management apps to allow health care professionals to make self-management app recommendations.

How does this study impact current management guidelines?

Asthma management apps should include multiple behavior changes techniques and have a high quality rating. Kiss myAsthma and AsthmaMD were the asthma management apps with the highest number of behavior change techniques and quality scores. Clinicians should review behavior change techniques and quality before prescribing an app.

TABLE I.

Examples of most frequently used BCTs in coded apps

BCT	Definitions and examples used in app
Behavior-health link	Information about the relationship between the behavior and health is described in the app.
	1. In the treatment and medications section, the text describes how “preventative, long-term control medications reduce the inflammation in your airways that leads to symptoms” (ASTHMA: Management).
	2. Treatment guidelines describe how “inhaled corticosteroids are very effective in decreasing the risk of asthma exacerbations” (Asthma: Health Care IT).
Consequences	The app provides information focusing on what will happen if the person performs the target behavior.
	1. The app includes information about asthma that describes how “preventers are taken every day to help prevent your asthma symptoms and flare-ups. They do this by reducing inflammation in your airways” (Kiss myAsthma).
	2. When describing the second yoga pose, the app says the upper body is stretched out, which “opens up your lungs and betters your breathing” (Home Remedies for Asthma: The Rockerz Group).
Others’ approval	Includes information in the app about what other people think about the target person’s behavior.
	1. App enables sharing ACT score report with physician (Asthma Test).
	2. Includes a link to join the YPA (Young People with Asthma) Facebook Group (Kiss myAsthma).
Instructions	The app tells the person how to perform a behavior or preparatory behaviors.
	1. When a person selects a yellow cloud to describe how he or she feels, the app says to “take your yellow zone meds! Call if not back to green in two days” (Asthma Action Hero).
	2. The FAQ section includes a question about how to know when to refill my child’s inhalers and says “the best way is to count the number of puffs given” (7 Keys to Manage Childhood Asthma Lite).
Model/demonstrate	Involves showing the person how to correctly perform a behavior in the app.
	1. Demonstrates inhaler technique (Wizdy Pets: Kids’ Asthma Game).
	2. Acupressure points video (Asthma Relief).
Self-monitoring	The person is asked to keep a record of a specified behavior in the app (eg, a diary).
	1. Log asthma medications and daily feelings (Asthma Logger).
	2. Record symptoms, peak flow, and rescue inhaler use (Asthma Monitor).
Feedback	The person receives data about a recorded behavior through the app.
	1. Provides a list or graph view of peak flow readings (My Breathefree).
	2. Provides reports of moods, symptoms, and medication use (Asthma Health Storylines).
Teach to use prompts/cues	The app teaches the person to identify environmental prompts that can be used to remind them to perform the behavior, including automated scheduled reminders (eg, push notification).
	1. Includes a push notification to remind users to record how he or she is feeling (Asthma Action Hero).
	2. User can set a calendar reminder to take medicine (My Breathefree).
Stress management	Included in the app are various specific techniques that seek to reduce anxiety and stress to facilitate the performance of the behavior.

J Allergy Clin Immunol Pract. Author manuscript; available in PMC 2020 November 01.

BCT	Definitions and examples used in app
	1. App mentions that deep breathing exercises can be used to reduce psychological stress (Treating Asthma: Asthma Treatment Guidelines).
	2. The app includes a section on managing anxiety and encourages user to stay active: “regular exercise, meditation and learning something new are all things that can help reduce symptoms of anxiety and depression” (Kiss myAsthma).

ACT, Asthma control test; *FAQ,* frequently asked question.

TABLE II.

Descriptions of asthma management apps

App name	Description
Asthma MD *	Allows users to log asthma symptoms, peak flow meter (PFM) readings, and medications, and share asthma log and peak flow data with physician. Graphical view of PFM and severity available. Disclaimer that app is not intended to substitute for medical advice and only a physician can diagnose asthma. Warning that personal data are collected and then encrypted.
Asthma Test *†	Allows users to monitor their asthma control by completing a 6-item self-report questionnaire about asthma symptoms in the past 4 wks. Ability to share the asthma control report with their providers via email. Users have to agree to share this data from Health with Asthma Test app (steps, inhaler use, respiratory rate).
Kiss myAsthma †	Designed for children and adolescents by researchers at the University of Sydney. Users can view asthma first aid tips, upload their asthma action plan, log and track medications and symptoms, set reminders, and identify goals (eg, reduce stress, get active, and improve inhaler technique) to help improve asthma control. Calendar available showing users' asthma severity, symptoms, asthma attacks, and mood over time. Encourages patient to print out a sample asthma action plan to share with provider.
My Breathe Free †	Users can track medications and PFM data. Provides information on triggers and includes clinic locator feature to find care nearby and video demonstrations on how to use various inhalers. User can enter provider email to send reports of peak expiratory flow reading.
Wizdy Pets	Designed for children and features a series of games to help children learn about managing asthma. Users perform tasks to take care of their virtual pet with asthma (ie, cleaning its home of triggers, giving the pet its inhaler, and recognizing when to give the rescue inhaler).
7 keys to manage childhood asthma Lite *	Identifies and provides information on 7 key aspects to managing asthma: avoiding allergens, relieving symptoms, control with controllers, difficult to control, modifying lifestyle, action plans, and monitoring response. Disclaimer that app is not a replacement for advice from a medical doctor.
Asthma Action Hero	A "mobile asthma action plan" that allows users to log asthma medications, asthma triggers, and daily asthma control (red, green, or yellow). Users receive pop-up reminders about actions to effectively control asthma (which inhalers to take, when to call 911) depending on the user-identified level of asthma control.
Asthma Storylines †	Allows users to track asthma symptoms, mood, and vital signs, write down questions for providers, set reminders for medications, and share progress with providers and caregivers by adding them to the app.
Asthma Tracker †	This app allows users to enter and monitor peak flow measurements, medication usage, and asthma symptoms. Offers reminders for peak flows, medications, and symptom monitoring, and has the ability to export data to be shared with providers and/or caregivers.
Home Remedies For Asthma (Rockerz group)	Contains information about asthma causes, symptoms, and triggers and identifies home remedies for treating asthma, such as essential oils, vitamins, and yoga poses.
Home Remedy for Asthma (StatesApps)	Contains information about home remedies for treating asthma, such as essential oils, herbs, foods, and teas. Disclaimer that users should consult a physician before following any advice.
Peak Flow	Allows users to log peak flow readings, comment about readings, and plot weekly or monthly data. Categorizes peak flow readings into red, green, and yellow zones on the basis of personal best values and provides the option to export data.
SaniQ Asthma	Allows users to track peak flow measurements, generate asthma diary reports to be exported, log medication use, and look up pollen levels in the area.
Asthma healthcare IT ±	Provides users with information about asthma attacks, asthma signs and symptoms, causes of asthma attacks, and treatment. Privacy policy that app may use personal data for analyzing service usage and for providing support and services to further the development of the services and products, and that it may combine personal data with nonpersonal data.
Asthma Guide (Nicholas Gabriel) *	Contains information about the types of asthma, home remedies, yoga, asthma attacks, and other alternative treatment recommendations. Disclaimer that the articles presented are for informational use only and are not a substitution for medical advice.
Asthma Management	Provides users with information on risk factors for asthma, triggers, symptoms, prevention, diagnostic tests, classification of asthma, and treatments, including specific types of medications.
Asthma Relief *	Provides users with an overview of acupressure and a 10-d treatment plan. Contains videos on how to apply the acupressure point and reminders to complete the daily massage. Disclaimer that the app is not a replacement for professional medical treatment.

Note: This table was added after the original search and 6 apps were no longer available for review: Asthma Logger, Asthma Monitor, Treating Asthma: Asthma Treatment Guidelines, Asthma Guide (Khonsuay), Asthma Tracker and Log, and Asthma Treatment Best Green Apps.

[*] Disclaimer that advice in the app is not a substitute for a physician.

[†] Apps that allow for or encourage data sharing with your physician.

[≠] Disclaimer that personal data may be analyzed.

J Allergy Clin Immunol Pract. Author manuscript; available in PMC 2020 November 01.

TABLE III.

BCTs used in coded apps

App name	BCTs															
	Behavior-health link	Consequences	Others' approval	Prompt intention formation	General encouragement	Instruction	Model	Review behavior goals	Self-monitoring	Feedback	Contingent rewards	Teach prompt	Prompt practice	Social support	Stress management	Total no. of BCTs
Kiss myAsthma	X	X	X	X		X		X	X	X	X	X			X	11
AsthmaMD	X	X	X			X	X		X	X		X				8
My Breathe free	X	X	X			X	X		X	X		X				8
Asthma Test			X		X	X			X	X		X				6
Asthma Action Hero *					X	X			X	X		X				5
Asthma Health Storylines *									X	X		X		X	X	5
Home Remedies For Asthma (Rockerz group) *	X	X				X	X								X	5
Asthma Guide (Nicholas Gabriel) *	X	X				X									X	4
Asthma Monitor *			X			X			X	X						4
SaniQ Asthma						X			X	X		X				4
7 keys to manage Childhood Asthma Lite	X	X				X										3
Asthma Guide (Khonsuay)	X	X				X										3
Asthma Logger *			X						X	X						3
ASTHMA: Management	X	X				X										3
Asthma Relief *						X	X					X				3
Asthma Tracker									X	X		X				3
Home Remedy for Asthma (States Apps)	X	X				X										3
Asthma (Health Care IT) *	X					X										2
Asthma Tracker & Log (Free)									X	X						2
Peak Flow									X	X						2
Treating Asthma: Asthma Treatment Guidelines	X														X	2
Wizdy Pets: Kids' Asthma Game							X						X			2
Asthma Treatment: Best Green Apps *	X															1
Total no. of apps using this BCT	12	9	6	1	2	15	5	1	12	12	1	9	1	1	5	

* XXX.

TABLE IV.

Mean scores for subscales on the MARS

App name	Available platform (s)	Means for subscales and overall scores on the MARS					
		Engagement	Functionality	Aesthetics	Information	Overall app quality	App subjective quality
Asthma Health Storylines *	Both	4.30	4.38	4.84	4.47	4.50	3.75
Wizdy Pets: Kids' Asthma Game	Both	4.00	4.50	4.67	3.80	4.24	3.25
AsthmaMD	Both	4.20	4.50	4.00	4.20	4.23	4.00
Kiss myAsthma	Both	4.20	4.00	4.67	4.00	4.22	3.25
SaniQ Asthma	Both	3.20	4.75	3.67	4.25	3.97	3.25
My Breathefree	Both	3.80	4.00	3.67	3.67	3.79	2.75
Asthma Action Hero *	Both	3.20	4.25	4.00	3.60	3.77	2.34
ASTHMA: Management	Android	2.60	4.75	3.33	3.80	3.62	2.00
Asthma Tracker	Both	3.40	4.00	3.00	3.67	3.52	3.25
Peak Flow	Android	3.20	4.00	3.33	3.40	3.48	2.50
7 keys to manage Childhood Asthma Lite	Both	2.80	4.00	3.33	3.40	3.38	1.50
Asthma Test	Both	2.20	4.75	3.00	2.60	3.14	1.50
Asthma (Health Care IT) *	Android	1.60	4.75	3.00	3.18	3.13	1.42
Asthma Relief *	Android	2.10	4.63	3.17	2.94	3.13	1.25
Home Remedies For Asthma (Rockerz group) *	Android	1.73	4.25	3.11	3.13	3.06	1.50
Home Remedy for Asthma (StatesApps)	Android	1.73	3.92	3.00	2.92	2.93	1.33
Asthma Treatment: BestGreenApps *	Android	1.70	4.00	2.67	2.40	2.77	1.63
Asthma Logger *	Android	1.80	3.33	2.56	2.89	2.73	1.50
Asthma Guide (Khonsuay)	Android	1.80	3.75	2.00	3.25	2.70	1.50
Asthma Tracker & Log (Free)	Android	2.20	3.00	2.33	3.20	2.68	1.75
Asthma Monitor *	Android	2.40	2.88	2.00	2.70	2.50	1.13
Treating Asthma: Asthma Treatment Guidelines	Android	1.80	3.50	2.00	2.50	2.45	1.00
Asthma Guide (Nicholas Gabriel) *	Android	1.70	4.00	2.00	2.40	2.43	1.00
All apps: mean ± SD	Both	2.68 ± 0.95	4.08 ± 0.53	3.19 ± 0.86	3.32 ± 0.61	3.32 ± 0.64	2.10 ± 0.94

*XXX.