

BRIEF REPORT

There is an “app” for that: Designing mobile phone technology to improve asthma action plan use in adolescent patients

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Abstract

Purpose: Asthma burden affects mortality, morbidity, quality of life, and the economy. Written asthma action plans are standard of care according to national guidelines, but these plans are often not prescribed. The purpose of this project was to develop an asthma action plan application for smartphones.

Data sources: A development studio was consulted for support in developing a smartphone application to code the software for the asthma action plan and assist in the design process. During development of the application, a survey was conducted to assist in design of the application and functionality.

Conclusions: All survey participants agreed that the application was easy to use, could be used without written instruction, and was designed for adolescents with asthma of any severity. Patients and providers mostly agreed that the app would help provide information about what to do in the event of an asthma exacerbation, and the application would be used frequently.

Implications for practice: There was consensus from both patients and providers that this application is not only functional but also helpful in the event of an asthma exacerbation. The project met the goal of designing a mobile phone application that would improve patient access to asthma action plans.

Introduction

Asthma is a chronic disease of the lower airways marked by recurrent episodes of coughing, wheezing, tightness in the chest, and dyspnea (National Heart, Lung, and Blood Institute [NHLBI], 2007). Despite the availability of improved pharmacological treatment options and advanced diagnostics, the rate of asthma exacerbations is increasing (Akinbami et al., 2012). Asthma incidence has increased by 15% over the last decade and is a significant and costly public health problem in the United States (Centers for Disease Control and Prevention [CDC], 2011). Asthma exacerbations result in approximately 2 million emergency department (ED) visits annually, with an average cost of \$1502 per visit (Wang, Srebotnjak, Brownell, & Hsia, 2014).

Adolescents (ages 12–19) are at particular risk of morbidity associated with asthma, as this population has a tendency to ignore or underreport symptoms, disregard treatment plans, and engage in risk-taking behaviors (Sadof, 2011). Approximately 12% of high school students were diagnosed with asthma in 2011 (CDC, 2011). Psychoso-

cial issues such as social anxiety, common in adolescents, pose a problem with medication adherence due, in part, to embarrassment of using an inhaled device (Kemp, 1999). Common behavior related to social anxiety seen among adolescents with asthma includes a tendency to ignore asthma symptoms and restrict activity rather than use inhalers to control symptoms, especially in the presence of peers (Asthma Burden, n.d.).

Personal asthma plans for patients, timely review of asthma care, and prescriptions of appropriate medications have been identified as primary intervention components for reducing asthma morbidity (Torjesen, 2014). Clearly, there is a need to educate patients about both level of asthma control and symptom control. Written asthma action plans are standard of care according to national guidelines, but these plans are often not prescribed (Global Initiative for Asthma, 2012). A promising intervention for initiating asthma action plans is the use of mobile phone technology. A recent study demonstrated that mobile phones were an effective method to assess asthma symptoms and medication adherence in adolescents

(Mulvaney et al., 2013). Having access to an interactive asthma action plan on a smartphone may increase the likelihood of asthma action plan usage, possibly averting asthma exacerbations. Therefore, the dual purpose of this clinical intervention was to (a) increase the rate of asthma action plan prescription rates among providers and (b) improve patient access to those plans in the event of an exacerbation.

Background

Current guidelines recommend that patients with asthma, regardless of symptom severity, receive a written action plan (NHLBI, 2007). It is estimated that only 10%–25% of patients with asthma receive a written asthma action plan (Beauchesne, Levert, El Tawil, Labrecque, & Blais, 2006; Rank, Volcheck, Li, Patel, & Lim, 2008). The most cited reason for provider failure to prescribe a written action plan is lack of time (Tolomeo, 2014). A recently published review of current literature regarding asthma management found that even when recommended by healthcare providers, patients are inconsistent in their use of written asthma action plans (Andrews, Jones, & Mullan, 2014).

Inconsistent patient use of asthma action plans may be related to the vast amount of information contained in the plans. Working memory accommodates limited amounts of information (Miller, 1956). For nearly 50 years, psychological and educational research has recommended organizing information into more meaningful units or *chunks* as a means to enhance memorization of material. The *chunking principle* applies to text, sounds, pictures, and videos. Proper use of the chunking principle has been found to improve retention and understanding of information (Harrod, 2014). To date, written asthma action plans do not utilize *chunking principle* (Miller, 1956). Thus, the amount of written information in the asthma action plan may seem insurmountable and unachievable to the patient. Written asthma action plans are printed on paper that patients must either commit to memory or keep with them at all times. Written plans may not be accessible at the time of an asthma exacerbation. Therefore, patients must rely on memory to retrieve large amounts of critical information during an acute and highly stressful time.

Mobile phones are ubiquitous. It is estimated that 90% of American adults have a cell phone, and 58% of American adults have a smartphone (Pew Internet Research Project, 2014). Unsurprisingly, 77% of adolescents aged 12–17 own a mobile phone, and this rate is even higher (87%) in older adolescents aged 14–17 (Pew Internet Research Project, 2014). Smartphone applications are readily available to a user with a mobile phone, and the format of the asthma action plan application could more easily break

up the information, thus applying the chunking principle. The use of a mobile application to help control asthma could provide a social norm for the adolescent patient. Increasing the utilization rates of asthma action plans may improve asthma-related health literacy among asthma patients, and subsequently reduce the number of asthma exacerbations.

Design

In order to address the limitations of the current protocol within a large allergy/immunology practice, a task force team was created to improve the existing written asthma action plans. Plans were routinely prescribed to adolescent patients, but these written plans needed to be incorporated within the electronic medical record. The task force included nurse practitioners, clinical managers, and technical support. The revised asthma action plan was redesigned for use within the electronic charting system. In addition, the clinical team revised the existing asthma action plan in an effort to make the plan more user-friendly for both providers and patients (Figure 1). For the revised asthma action plan, the language within the body of the document was edited and the overall format was changed to make printed versions visually engaging. Furthermore, drop-down boxes were added to include the available prescription medications for asthma management. These boxes were designed to make the asthma action plans easier for providers to complete during a patient's office visit.

The new asthma action plan clarified the required green, yellow, and red zone symptoms. A section was added to include instructions on what to do for patients who experience asthma symptoms with exercise. The yellow zone instructions were clarified and a sentence was added, which advised patients to contact the practice office in the event rescue medication is used more than two times per week. According to the NHLBI Guidelines, asthma is considered uncontrolled if patients use rescue medication more than two times per week or have episodes of nighttime awakening symptoms (NHLBI, 2007).

However, the new electronic version of the asthma action plan posed limitations (Table 1). The overall appearance of the plan, while vastly improved from the original written plan, contains copious amounts of information and was difficult for patients to comprehend. To improve the functionality and accessibility of the asthma action plan, it was decided that a mobile phone application might serve both purposes. Smartphone applications are readily available to patients with a mobile phone, and the format of the application could more easily break up the information and *chunk* critical information into meaningful and manageable bits of data for the user of the application. A local development studio was consulted for support in

GREEN ZONE: Doing well No Breathing Difficulties • No Coughing • No Wheezing • No Shortness of Breath • No nighttime awakening • Able to do usual activities (work, play, exercise) IF using peak flow: Peak flow is more than 80% of personal best: (_____)	CONTROLLER MEDICATIONS Listed medication(s) are DAILY controller medication(s) <table border="0"> <thead> <tr> <th align="left">Medication</th> <th align="left">Directions</th> </tr> </thead> <tbody> <tr><td>1.</td><td></td></tr> <tr><td>2.</td><td></td></tr> <tr><td>3.</td><td></td></tr> <tr><td>4.</td><td></td></tr> </tbody> </table> For exercise-induced symptoms, add ☐	Medication	Directions	1.		2.		3.		4.	
Medication	Directions										
1.											
2.											
3.											
4.											
YELLOW ZONE: Caution Mild Breathing Difficulties • Cough • Wheeze • Shortness of breath • Waking from sleep because of these symptoms • Some activity limitation because of breathing difficulty IF using peak flow: Peak flow is 60%-80% of personal best (_____ to _____)	QUICK-RELIEF (RESCUE) MEDICATIONS • Continue daily controller medication(s) as prescribed • Add 2-4 puffs of _____ or nebulizer treatment • Recheck symptoms and/or peak flow after 15 minutes • If symptoms improved and peak flow within normal range, return to Green zone • If symptoms persist, add the following medication(s): ☐ • If symptoms and peak flow remains low after 3 days, call the office for further instruction										
RED ZONE: Medical Alert Severe Breathing Difficulties • Breathing is hard and fast • Extreme shortness of breath • Cannot do usual activities • Difficulty talking or walking • Rescue medicine not helping • Symptoms worsening ┘ IF using peak flow: Peak flow is less than 60% of personal best (_____)	MEDICAL ALERT! Take these medications and then CONTACT OUR OFFICE NOW! 1. 2. If symptoms are GETTING WORSE or NOT IMPROVING, go to the hospital or call 9-1-1 CALL OUR OFFICE ***-***-*** 1-800-***-***										

Figure 1 Electronic asthma action plan created by taskforce.

developing a smartphone application to code the software for the asthma action plan and assist in the design process.

The design process involved creating screenshots of the asthma action plan that would fit within the functionality of the application (Figures 2–5). These screenshots became the blueprint for the software team to create the application. The new asthma action plan application was adapted into a format that would be more accessible to patients during an asthma exacerbation. The application allowed for the red, yellow, and green zone instructions to be divided into different screenshots, thus chunking the information into bits that were more manageable to un-

derstand. Importantly, the application allows providers to program the individual patient's plan of care directly into their phone. Additionally, patient users of the asthma action plan application have the ability to type in their peak flow and be directed to either the green, yellow, or red zone.

During the development process, it was decided that the application should have a design that was appealing to children and simple to understand. The login process involves both patient and nursing staff or provider within a practice. The application simplifies asthma care for both patient and provider by specifying a list of controller

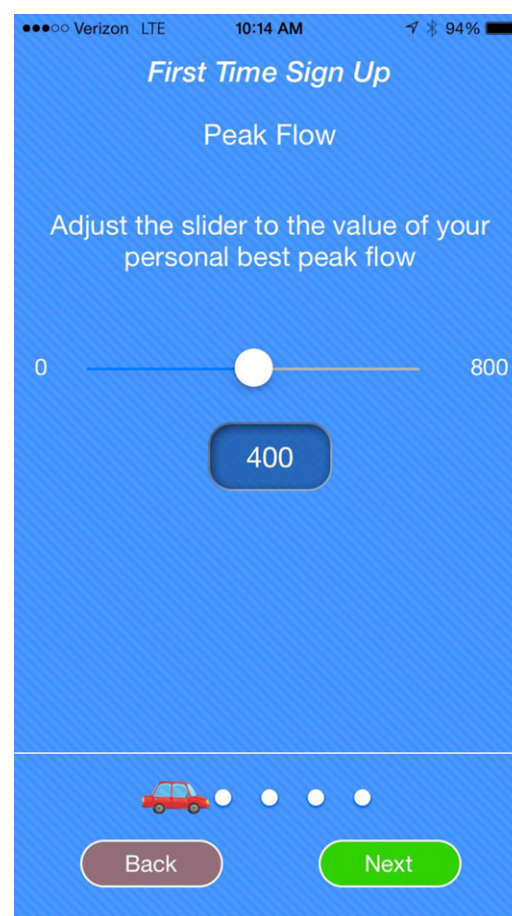
Table 1 Comparing traditional written asthma action plans to the asthma action plan application

Features of asthma action plan	Written asthma action plans	Asthma action plan application
• Instructions on daily controller medication	Yes	Yes
• Instructions to determine if asthma is worsening	Yes	Yes
• Instructions for treatment plan in the event of a mild exacerbation	Yes	Yes
• Action to take in the event of severe exacerbation	Yes	Yes
• Data accessible as meaningful chunks (easy to use)	No	Yes
• Available at time of exacerbation on patient's phone	No	Yes
• Personalized list of triggers within action plan	No	Yes
• Ability to contact provider or emergency services directly from asthma action plan	No	Yes

medications and rescue medications in a drop-down box format. The Asthma Control Test (ACT) was added as a feature to track patient's asthma control on a monthly basis. A terms and conditions statement was created for use within the application. The terms and conditions statement protects both developer and software company from litigation involving misuse of the application. Furthermore, it implies consent by the user via an electronic contract.

Methods

In an effort to improve the functionality of the application, patients and providers within an allergy practice completed a survey (Figure 6). The survey design was approved by the Vanderbilt Institutional Review Board and assessed the ease of use and design of the application as well as whether the survey participants believed that this application would enhance their ability to use their asthma action plan in the event of an asthma exacerbation. The survey assessed the patient's familiarity with smartphone applications and whether the asthma action plan applica-

**Figure 2** Screenshot of the application—patients can set the value of their personal best peak flow.

tion was easy to use. Data from these surveys were compiled using an Excel spreadsheet. The qualitative feedback was analyzed to determine any areas of improvement needed within the application. The surveys helped gain insight into any areas within the application that may be confusing or difficult for adolescents to use.

Participants for the survey were chosen from a pool of patients returning for follow-up care at the allergy/immunology practice. Inclusion criteria for survey participants included age between 12 and 19, previous diagnosis of asthma, and willingness to complete a short survey. Patients were excluded from the survey if they had never been prescribed a controller medication for their asthma. The mean age of the patients ($N = 12$) completing the survey was 14.5 years, and 60% of participants were female. In addition to the patient participants, five providers within the allergy practice completed the survey.

Ninety-four percent of survey patient participants owned a smartphone. Patients completing the survey

Figure 3 Screenshot of the application—provider will input specific patient medications.

Figure 4 Screenshot of the application—provider may identify specific triggers of patient's asthma.

($N = 100\%$) noted the application was easy to use and could be used without any written instruction. Furthermore, the patients believed that the use of the application simplified the instructions contained within the asthma action plan as compared to the written plan of care. One father of a girl with asthma expressed anxiety relief, as he believed he would have a much better understanding of action to take if his daughter experienced an asthma exacerbation. Patients reported only positive findings regarding the functionality and design of the application (Table 2).

The providers completing the survey were physicians and nurse practitioners working in an allergy/immunology specialty practice. The results of the survey received from providers during the feedback process concerned the use of the application during an office visit. There was concern among providers about the workflow surrounding the use of the application during an office visit. As mentioned previously, the primary reason for failure to prescribe an asthma action plan is time (Tolomeo, 2014). Providers be-

lieved that the application should communicate with electronic medical records to improve efficiency. This does not concern patient interface with the application, but it is critical that this information be documented for billing purposes and future reference by the practice. This concern has been addressed and remedied with assistance from the software design team.

Implications for nursing practice

Patient education is a key component to the success of this project. The workflow of integrating the application into patient care involves both nursing staff and advanced practice nurses. In order for the patient to properly use this application, they must first be trained on the importance of an asthma action plan and then how to operate the action plan application on their smartphone. It is proposed that patients will download the application from the "app store" on either an iPhone or Android during their



Figure 5 Screenshot of the application—home page for patient after initial sign on process.

office visit. The provider will determine appropriate medications for the patient's asthma action plan, and either the advanced practice nurse or a member of the nursing staff will walk the patient through the programming of medications and instructions within the application. This process will ensure the patient has correct information on their phone in addition to allowing for an opportunity to clarify the difference between rescue inhalers and controller medication. The providers will then have access to the patient's information on a web portal that tracks peak flows and red, yellow, and green zones when patients login and use the application.

Social cognitive theory (SCT) is a model of behavior that was chosen for the framework of this project based on the unique applicability to patient education regarding chronic disease management. The theory is based on the idea that there are both personal and environmental influences on behavior, and these influences interact in a bidirectional manner (Bandura, 1991). SCT holds the idea that patients learn through observation (Denler, Wolters, & Benzoni,

2014). Observational learning can occur via direct modeling of behavior, demonstrations of a particular skill (e.g., proper inhaler technique), or videos or pictures of the desired behavior. The patient must have environmental and personal support along the way. If there are factors that prevent the patient from observing healthy behaviors, the healthcare provider may find it difficult to intervene.

Another factor in behavior modification in SCT is outcome expectations. Patients must have both realistic outcome expectations and positive outcome expectations for them to have motivation to change their behavior. If the patient does not believe that he can improve his health through certain behaviors, he is unlikely to proceed with any interventions. This is true for goal setting as well. The goals for the patient must be obtainable.

Perceived self-efficacy is the patient's belief that he can make a difference in his own health. Self-regulation is the process that the patients take to monitor their own progress and modify behavior along the way. If the patient does not believe that his asthma will improve with trigger avoidance, regular use of inhaled corticosteroids, and early intervention for exacerbations, he will be less likely to be compliant with any of these actions. This is an example of a patient with a poor perception of outcome expectations, self-efficacy, and self-regulation. On the other hand, a patient who is educated about the importance of these self-regulatory actions and adopts the belief that it is important to follow the advice of the healthcare professional will have a better likelihood of asthma management.

Asthma is a chronic disease with intermittent periods of wellness and exacerbation. In order for patients with this illness to maintain control of their disease, they must have proper education on the importance of self-management. SCT provides the framework for creating an empowered patient, and it is through the collaboration of nurse and patient that this can occur.

Strengths and limitations

Feedback from patients and providers was in agreement regarding the functionality of the application and ease of use. The initial evaluation survey regarding the asthma application was overwhelmingly positive and constructive by both patients and providers. The initial number of those surveyed was small, and the survey participants were patients of the individual administering the surveys. This could have imposed some level of bias on the results. Formative evaluation will continue to be used to assess for both potential concerns and ideas for application upgrade.

One of the project delays was the need to ensure HIPAA (Health Insurance Portability and Accountability Act) compliance while avoiding a hindrance to patient accessibility. A terms and conditions statement must be

Your familiarity with using apps:

Use them all the time	Often use them	Sometimes use them	Have a few and barely use them	Don't have my own, but have used some friend's apps	Never use them	What's an app?
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If you use an app, please choose the answer that best represents your experience:

I found the Asthma Action Plan app easy to use:

Agree	Somewhat Agree	No Opinion	Somewhat Disagree	Disagree
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I can use the app without written instructions:

Agree	Somewhat Agree	No Opinion	Somewhat Disagree	Disagree
Areas that need further instruction				

The app does everything I would expect it to:

Agree	Somewhat Agree	No Opinion	Somewhat Disagree	Disagree
Functions that you would like to see expanded				

Figure 6 Evaluation tool for asthma action plan application.

modified to include language that patients are aware of the risk that personal health information (PHI) can be viewed on the application. The patient will be able to opt out of logging into the application each time it is viewed. However, this may make the PHI accessible to anyone who might have access to the patient's smartphone. Unfortunately, requiring a username and password every time a patient opens the application would effectively eliminate the functionality of the application. This extra step would certainly not enhance accessibility to the action plan in the event of an asthma exacerbation.

Additionally, servers collecting this PHI must be HIPAA compliant. This also created a short delay in the development process when all data had to be transferred from Parse to Catalyze. These steps made it necessary to engage an attorney focused on HIPAA regulations in order to ensure compliance. Once all legal implications are resolved, the application will be ready for use in a clinical setting.

Future practice implications

The collaboration of a healthcare professional and software engineer was necessary to create this asthma action

plan application. A gap in the existing healthcare delivery model for asthma care was identified after years of experience working with patients with asthma. Partnering with a software engineer and design team helped the mobile application have a better appearance and enhanced features to improve user experience. This teamwork resulted in a product that was both purposeful and user-friendly.

The initial plans to disseminate this project include licensing the application software to the Allergy, Asthma, and Sinus Center in Knoxville, Tennessee. If the application is successful in this practice as evidenced by increased prescription rates of asthma action plans, the application will be marketed to other allergy and pulmonary practices. The future practice implications of the application are almost endless. There is potential for a large number of patients to have access to the application through use in the Knoxville allergy practice. Additionally, expansion to other practices around the region and nationally would hopefully help every asthma patient have better access to a plan of care in the event of an asthma exacerbation. EDs could also utilize this technology to prevent return visits from their asthma patients.

Additionally, there are opportunities to use this technology in research. Determining the success of mobile

Table 2 Key comments from survey participants

Key comments
"This would be helpful, especially if you didn't have your paper copy"
"Love that it is portable. I like that you can call the office and 911 directly from the phone"
"This would be a good thing to use/ Include chest tightness under the yellow zone instructions"
"I think that my mom would like it a lot"
"Incorporate a reminder to do peak flow or medication; some way to track patient information; have some sense of fear within the app so patients take it seriously; possibility to communicate with office via a database"
"I think that it is a good idea"
"I would like to see some incorporation of peak flows on the first page"
"The login process is somewhat tedious"
"This needs to be translatable to EMR to make it easy to use"
"I like the little car"
"I think that a medication reminder might be helpful, or maybe a reminder to use the app"
"There needs to be a way to communicate the information to the provider during office visits- maybe a symptom tracker"
"I would use this much more than my paper copy. I don't even know where that is!"
"I think my Mom would feel better if I had this- she wouldn't worry so much"
"It would be nice to be able to print this in addition to giving it to the patient"
"I would like to see an education piece within the app in addition to the action plan"
"Love it!"

phone technology in asthma management would have implications for other chronic illnesses. If the application were successful in preventing visits to the ED, there would be cost savings to the patient and population. This information could be translated into care of patients with diabetes, congestive heart failure, and other health conditions requiring patients to be aware of their own symptoms for management purposes.

Conclusions

The success of this project was the result of a collaborative approach between an advanced practice nurse, patients with asthma, and a software engineer. This collaborative team approach allowed for the best possible product. A gap in the existing healthcare delivery model for asthma care was identified after years of experience working with patients with asthma. It is clear from the literature that asthma action plans are critical for control of this chronic illness, but written action plans are underutilized (Torjesen, 2014). Partnering with patients, a software engineer,

and design team helped the mobile application have a better appearance and enhanced features to improve user and provider experience. This teamwork resulted in a product that was both purposeful and user-friendly. Advanced practice nurses have a unique perspective of the gaps in the healthcare system, and it is crucial that partnerships are created with both patients and professionals to solve these problems and develop innovative solutions for demanding healthcare problems.

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