Journal of Asthma

ISSN: 0277-0903 (Print) 1532-4303 (Online) Journal homepage: http://www.tandfonline.com/loi/ijas20

Understanding clinicians' attitudes toward a mobile health strategy to childhood asthma management: A qualitative study

Jessica P. Hollenbach, Anna Cushing, Emilie Melvin, Bryanna McGowan, Michelle M. Cloutier & Melissa Manice

To cite this article: Jessica P. Hollenbach, Anna Cushing, Emilie Melvin, Bryanna McGowan, Michelle M. Cloutier & Melissa Manice (2017) Understanding clinicians' attitudes toward a mobile health strategy to childhood asthma management: A qualitative study, Journal of Asthma, 54:7, 754-760, DOI: 10.1080/02770903.2016.1263649

To link to this article: http://dx.doi.org/10.1080/02770903.2016.1263649

Accepted author version posted online: 23 Nov 2016.
Published online: 23 Nov 2016.

Submit your article to this journal

Article views: 192

View related articles

View Crossmark data

Full Terms & Conditions of access and use can be found at
http://www.tandfonline.com/action/journalInformation?journalCode=ijas20

Download by: [University of Liverpool] **Date:** 13 October 2017, At: 07:28

JOURNAL OF ASTHMA
2017, VOL. 54, NO. 7, 754–760
http://dx.doi.org/10.1080/02770903.2016.1263649

Taylor & Francis
Taylor & Francis Group

Understanding clinicians' attitudes toward a mobile health strategy to childhood asthma management: A qualitative study

Jessica P. Hollenbach, PhD, AE-C[a], Anna Cushing, BS[b], Emilie Melvin, BS[c], Bryanna McGowan, BS[c], Michelle M. Cloutier, MD[d], and Melissa Manice, PhD, MPH[b]

[a]Department of Pediatrics, University of Connecticut School of Medicine, Asthma Center, CT Children's Medical Center, Hartford, CT, USA; [b]Icahn School of Medicine at Mount Sinai, CoHero Health, New York, NY, USA; [c]CoHero Health, New York, NY, USA; [d]Department of Pediatrics and Medicine, University of Connecticut Health Center, Asthma Center, Connecticut Children's Medical Center, Hartford, CT, USA

ABSTRACT

Objectives: Mobile technology for childhood asthma can provide real-time data to enhance care. What real-time adherence information clinicians want, how they may use it, and if the data meet their clinical needs have not been fully explored. Our goal was to determine whether pediatric primary care and pulmonary clinicians believe if a sensor-based mobile intervention is useful in caring for patients with asthma. *Methods*: We recruited participants from 3 urban, primary care and 1 pulmonary practice from July to September 2015 in Hartford, CT. Forty-one participated in four focus groups, which included a demonstration of the technology. Participants were probed with open-ended questions on the type, frequency, and format of inter-visit patient information they found useful. *Results*: 41 participants (mean age 49 (±13.7) years) were board-certified clinicians (41% MDs and 20% mid-level practitioners), practiced medicine on an average of 19 (±14) years, were primarily white (59%) and women (78%). Clinicians wanted 1) adherence to prescribed inhaler therapy and 2) data on inhaler technique. Clinicians wanted it at the time of a scheduled clinic visit but also wanted inter-visit alerts for excessive use of rescue therapy. Pulmonologists liked the mobile spirometer's provision of inter-visit lung function data; pediatricians did not share this view. Concerns with data accuracy were raised due to families who shared inhalers, access to smartphones, and protection of health information. *Conclusions*: Overall, clinicians view an asthma mobile health technology as enhancing the patient-centered medical home. Pediatric primary care clinicians and pulmonologists want different information from a mobile app.

ARTICLE HISTORY
Received 7 July 2016
Revised 26 September 2016
Accepted 17 November 2016

KEYWORDS
Adherence; children; mHealth; self-management

Downloaded by [University of Liverpool] at 07:28 13 October 2017

Introduction

Asthma affects 26 million Americans, including approximately 10% of US children (7.1 million children) [1]. Current asthma guidelines recommend daily controller therapy for children with persistent asthma and a stepwise approach to long-term asthma management, especially in children, to achieve and maintain asthma control [2]. Optimal adherence to inhaled corticosteroids requires patients to take their preventer medication at least 80% of the time [3]. Non-adherence to controller medication is common, with current estimates of non-adherence estimated as 45% with adherence to asthma therapy among adolescents as low as 42% [4,5]. Adherence rates to preventer medication improve with age, making young people, particularly adolescents, an especially at-risk group.[6–8].

Low adherence to asthma therapy contributes significantly to the 1.8 million yearly emergency department visits for asthma and the $50 billion dollars in annual direct health care costs in the United States [9]. Lower adherence results in overuse of reliever medication, increased asthma symptoms, more frequent asthma attacks (exacerbations), and increased emergency department visits and hospital admissions.[10,11]. In Canada, more than $1.6 billion US dollars of asthma care costs can be directly attributed to medication non-adherence [12].

Inattention and forgetfulness are the most commonly cited reasons for poor adherence to prescribed pharmacotherapy in the adolescent population [13]. Fortunately, adolescents are most likely to use new technologies and thus may be most able to adopt a mobile technology-based solution aimed at improving adherence [14]. A recent survey of adolescents and caregivers at a pediatric clinic showed that a majority were interested in using mobile health apps though only 17% and 35%, respectively, currently use a mobile health app [15]. This difference between interest and current use of mobile

CONTACT Jessica P. Hollenbach jhollenbach@connecticutchildrens.org Department of Pediatrics, University of Connecticut School of Medicine, Asthma Center, CT Children's Medical Center, 282 Washington Street, Hartford, CT 06106, USA.

© 2017 Taylor & Francis

health apps demonstrates the pressing need for further app development and patient education on available mHealth resources [15].

Factors that have been shown to improve adherence include long-term partnership between patients and health care providers to ensure clinicians have the information needed for personalized treatment [13]. Currently, when a patient's asthma does not respond to medication, it is difficult for providers to determine whether this is because a different dose or medication is needed or because the patient is not receiving sufficient medication for asthma control due to non-adherence and/or incorrect medication use technique. Clinicians must rely on patient self-reported medication use for clinical decision-making, which has been shown to overestimate adherence compared to actual medication use measured by electronic monitoring [16,17]. Patients with the lowest adherence are least likely to provide accurate information to their providers but have the largest potential benefit from medication reminders and education [7]. This lack of objective data makes it difficult for clinicians to make effective clinical decisions that could greatly benefit their patients.

Coherohealth has developed a mobile health platform for asthma adherence. The platform consists of an inhaler sensor to track real-time medication use, a mobile health (mHealth) application (app) to remind and engage patients, and an FDA-approved mobile spirometer to coach patients for self-measurement of lung function. In addition, Coherohealth is currently developing a "smart spacer" device that functions as both a medication delivery spacer and an embedded sensor to assess both real-time adherence and quality of medication administration. Adherence data from a patient's inhaler sensor or smart spacer and lung function data from the mobile spirometer can be pushed to clinicians via Health Insurance Portability and Accountability Act (HIPAA)-compliant servers, enabling data-driven clinical decisions. However, whether primary care pediatricians and pediatric pulmonologists find the Cohero mHealth technology useful is unknown. The effectiveness of mHealth apps in improving patient adherence to asthma therapy [18–21] has been demonstrated, but few, if any, have elicited feedback from clinicians [22]. The purpose of this study was to investigate the attitudes of pediatric primary care clinicians and pulmonologists toward an mHealth strategy aimed at enhancing treatment ownership and adherence in children with chronic asthma. Our objective was to better understand clinician preferences for the type of inter-visit patient information that would be most useful in guiding in-clinic treatment decisions and the best way, and frequency, to provide clinicians with patient reports.

Methods

The study was conducted between July and September 2015 in Hartford, CT, and elicited feedback from pediatric primary care clinicians and pediatric pulmonologists who serve a primarily urban, low-income population disproportionately affected by asthma. The study was approved by the Institutional Review Board at CT Children's Medical Center and was funded by the Connecticut Children's Medical Center.

Focus groups

We convened four focus groups; three with clinicians who worked in three different pediatric primary care clinics and one with a pediatric pulmonology practice, all located in Hartford, CT. The rationale for including multiple types of clinicians in the focus groups comes from the team-based approach that pediatric clinics/practices use to care for patients with asthma. In pediatric practices, all types of clinicians participate in providing asthma care including physicians, mid-level nurses especially telephone triage nurses. All these individuals could use information from the app, and we view this as a strength of our study. We also knew that clinics employed triage nurses as part of their asthma call workflow and that we wanted to capture their feedback. Finally, we also wanted to capture the feedback from respiratory therapists working in the pulmonary clinic.

Practices were recruited via email solicitation. All clinicians provided care for low-income, underserved children with asthma living in Hartford. The groups were facilitated by a certified asthma educator (J.H.) and a pediatric pulmonologist with expertise in focus group design (M.M.C.). An expert in mHealth and founder of Coherohealth (M.M.) was present for the sole purpose of providing a description of the mHealth app and to answer specific questions regarding functionality of the mHealth technology. Focus groups were conducted over breakfast or lunch at the practice site, which was provided by the facilitators. Participants received $50 for their time.

Based on a detailed review of the literature on the attitudes of clinicians toward mHealth strategies, a multidisciplinary team developed open-ended questions as a guide for discussion. These were refined and modified in light of the findings of our initial focus group and reviewed as themes emerged from the focus groups. During the course of each focus group, an anonymous survey was distributed to collect demographic data and ratings on perceived patient acceptability of the app and sensor, what percentage of their patients were prescribed a spacer with their inhaler, and how likely they thought their patients would be to use home spirometry. A short demonstration of the mHealth app and technology was

Downloaded by [University of Liverpool] at 07:28 13 October 2017

presented at the beginning of each focus group to familiarize participants with the focus group subject matter. Images and description of the smart spacer were used for the presentation because they are still in development. Focus groups were recorded and lasted between 60 and 90 minutes. 2 moderators (JH and MMC) participated in the 60- to 90-minute recorded discussion in keeping with focus group convention [23].

Data analysis

Digitally recorded audio files from the focus groups were fully transcribed. Investigators analyzed the focus group transcripts, in consecutive order, until they arrived at the judgment that data saturation had been achieved and further analysis of the transcripts would not offer any new information. Saturation is the standard by which sample sizes are determined in qualitative health science research. Data analysis was iterative, and emerging themes were used to guide the discussions of subsequent focus groups using the thematic approach outlined by Krueger [24]. Transcripts were analyzed to identify clinician's perceptions toward the usefulness of an mHealth strategy in managing chronic pediatric asthma. Transcripts were compared with recorded files to correct transcription errors. Focus groups were clustered by primary care or pulmonary clinic.

Several procedures were implemented to ensure validity and trustworthiness of the content analysis performed on the focus group transcripts. Two members of the research team who did not attend the focus group sessions independently read each transcript before coding data. Each reviewer coded data by focus group question and prepared summaries of all the data on emergent themes as outlined by Krueger [24]. After independently coding the transcripts, the two reviewers compared their findings to reach consensus on coding differences using a modified Delphi approach. If the 2 reviewers could not achieve consensus on coding, a third reviewer was identified to adjudicate the differences in classifying major and minor themes in the transcripts.

To support the major themes and interpretations drawn from these focus groups, quotes from participants are included in the text and are identified as to source (primary care or pulmonary specialty) and presented in italics.

Results

Participant characteristics

Forty-one clinicians participated, representing 79% of all clinicians in the 4 practices (Table 1). In general, participants were on average 49 (±13.7) years old, primarily white (59%) and women (78%) and practiced medicine for an average of 19 (±14) years.

Table 1. Demographics of focus group participants.

	$N = 41$
Age in years, mean (±SD)	49 (±13.7)
# of years in practice	19±14
Race/ethnicity	
White	59%
Hispanic	22%
Female sex	78%
Clinician type	n (%)
Pulmonologist	5 (12%)
Pediatrician	12 (29%)
Physician assistant	2 (5%)
APRN	6 (15%)
Other	16 (39%)
Medical assistants	5 (12%)
RN, BSN, LPN	7 (17%)
Unknown	4 (10%)

Type of adherence information wanted

Clinicians found the mHealth app and sensor useful for providing data on adherence to prescribed inhaler therapy during the inter-visit period. In particular, clinicians wanted information on the frequency of rescue medicine use in relation to controller use. One representative example of clinician's enthusiasm regarding access to adherence data is as follows:

> *Compliance – if they're using it. Because they come in and they're not using it, particularly the preventive medications. And how much they're doing it – is it twice a day, once a day …(Primary care)*

It was clear that pediatricians did not want every data point regarding inhaler actuation.

> *I don't really want all that rescue inhaler information, except when my patient on a controller med is now over using their rescue and then I want to see what they're doing with their controller. (Primary care)*

In contrast, pulmonologists wanted more information and more detailed information (ie, every single data point on actuation of both rescue and controller therapy). In addition, they also wanted this information in the context of a patient's self-reported symptoms.

Frequency of data sharing

Overall, clinicians expressed concerns with having data from the inhaler sensor, mobile spacer, or mobile spirometer automatically pushed to their electronic health record (EHR) in real time. In particular, some were concerned with being liable for data sent between visits during a time when the clinician could not respond. Rather, clinicians wanted the data to be pushed directly into their patient's

Downloaded by [University of Liverpool] at 07:28 13 October 2017

Downloaded by [University of Liverpool] at 07:28 13 October 2017

chart into the EHR immediately prior to the patient's clinic visit.

> *I think at the visit it's very helpful because sometimes the families can't tell me how much they're using or how often but then to have information to tweak their plan …(Primary Care)*

How should data be displayed/presented?

Three of the four practices were currently using an EHR to manage their patient charts. Because of the ease of having all data in one system, all clinicians wanted the data to be pushed directly into the EHR and automatically linked to a patient's chart. The pulmonary division had just recently transitioned to an EHR and thought that the technology could improve their office workflow:

> *If we can get anything pushed into (sic) our EHR we will buy it …(Pulmonary)*

Clinicians believed that separate graphical reports of patient-specific controller and rescue adherence data that could be customized would be very useful. Clinicians liked that alerts could be set up based upon a certain threshold (ie, rescue inhaler use >2 times a week) that would indicate not well-controlled asthma, as well as observe trends over time to elucidate any seasonal trends that could be useful in educating patients.

> *Longer like a year anyway, because maybe I can show them like look how when you were feeling good what it(graph of adherence data) looked like and now you're not feeling so good anymore and this is what it looks like, and there's a difference …(Primary Care)*

Usefulness of mHealth to observe practice trends

Primary care pediatricians believed that the Cohero app could be useful in helping to benchmark provider behaviors against other clinicians within the practice, but were unsure if benchmarking would improve patient care. Similarly, data from the app could support a practice's adoption and implementation of the patient-centered medical home (PCMH) model and inform quality improvement efforts. The ability of data from the app to inform medical education practices was seen as a benefit.

> *The other big windmill is medical education. You're think about teaching your patients, teaching their parents, teaching the school nurses that do the spirometry about this, teaching residents, about how to use, and implementation, or seeing pre post, I know it's kind of a lot of variables but it's like I'm [being judged] by how [my] patients do …[via] chart reviews, outcomes, how many of your patients end up in the ED … (Primary Care).*

Usefulness of mobile spirometer

Overall, primary care pediatricians believed inter-visit lung function may be helpful but did not believe it to be a top priority. Rather, pediatricians in the focus groups preferred inter-visit adherence data to prescribed inhaler therapy.

> *I mean compliance is high on my list, and then compliance, and then compliance, and then compliance, and then compliance, and then, since you brought it up (lung function) okay, but it's not top on my list …(Primary Care)*

However, pediatricians did believe that the mobile spirometer may be useful in replacing peak flow meters.

Peak flow is a thing of the past (Primary Care)

In contrast with pulmonologists, pediatricians would only want interpreted spirometry results that are put into a clinically usable context. Pulmonologists found the mobile spirometer functionality very appealing, particularly for their patients with severe persistent asthma who were not well controlled and who may be high or low perceivers of symptoms.

Usefulness of a smart spacer

Pediatricians and pulmonologists thought that the smart spacer would be exceedingly useful for several reasons. The smart spacer may assess and provide coaching on a patient's inhaler technique.

Learning to use the inhaler and spacer correctly, that will go a long way. (Primary Care)

> *And I had a patient that was compliant with her inhaler and her spacer, dutifully putting in mouth and yet- [sound-breathing out instead of in]- every single time- I would have found that. (Primary Care)*

The smart spacer was also thought to be particularly useful in helping to demonstrate and convince parents of young children that drug delivery with a spacer is improved, eliminating the parent's perceived need for a nebulizer.

Unanticipated themes

Several minor themes emerged from the focus groups that were unexpected but repeated across groups. One was the pediatrician's concern with data accuracy among families who may share inhaler medication or who have multiple inhalers in different locations (ie, one at home and one at school). The second was the anxiety expressed by pediatricians and pulmonologists in the mHealth app onboarding process. Essentially, clinicians wanted to understand how the implementation of the mHealth app and technology would affect their workflow and who would be responsible for training practice staff and families in how to set up, use, and respond to all components of the technology. Third, there was concern about patient's access to smartphones, particularly around the end of the month when plans expire and phones get deactivated. Patient privacy concerns were expressed as well. Finally, clinicians

were interested in the ability of the mHealth app to provide continuity of care across the spectrum of caregivers, particularly school nurses.

> *And then for the little kids who don't have their own smart phone, I think using this in a school would probably be beneficial because the nurse is watching them do these things also and like, I don't know, I guess you could capture a big group of kids doing it at the same location. (Pulmonary)*
> *Some sort of integration with the school piece is critical because I think a lot of our families minimize or ignore symptoms at school, or I mean at home, but at school they are actually getting addressed a little more. And so they, if they are getting their albuterol three times a day at school, families should be notified, but we wouldn't be capturing that here. (Pulmonary)*
> *You may have a number of caregivers including the school nurse, the coach, the babysitter, mom, dad, uncle Charlie, who are all kind of helping administer medication at all varying degrees of efficacy and skill. (Primary Care)*

Discussion

This study supports our hypothesis that pediatricians, pulmonologists, and mid-level practitioners agreed that the mHealth app and sensor-based technologies (inhalers, spacers, and spirometers) could be useful in managing their patients with asthma. They reported that the most significant benefit would be the ability to obtain real-time inter-visit data on adherence to their patient's prescribed inhaled therapy for asthma. The ability to customize report frequency by individual patient and the ability to set alert thresholds based on frequency of rescue inhaler use or the proportion of controller vs. rescue inhaler use were viewed as filling an important gap in achieving well-controlled asthma. Providers had some reservations on data accuracy due to the possibility of shared inhalers and concerns with protection of data privacy. Similar to findings from Pinnock et al. where asthma care providers saw value in keeping long-term lung function records to facilitate professional reviews [22], clinicians in our study welcomed the ability to use adherence and lung function data for benchmarking purposes, quality improvement efforts, and to adhere to PCMH standards.

Our study recruited participants from four urban practices located in Hartford, CT. Thus, participants may not be representative of other pediatric primary care and pulmonary practices who may serve patients belonging to a different socioeconomic class or who work within different healthcare systems. Clinicians who agreed to participate in the focus groups may have been more likely to adopt an mHealth strategy to aid in the provision of asthma care although more than 75% of all the clinicians at each of the sites participated. Accordingly, more than half reported likelihood in using results from the mobile spirometer to manage their patient's asthma. Likewise, almost two-thirds of clinicians believed that their patients would be willing to use the sensor and mHealth app. Other limitations include the potential for social desirability bias as participants were provided a meal over breakfast or lunch and monetary remuneration for their time. Though not a focus group facilitator, the presence of the CEO of Coherhealth during the focus groups may have also introduced social desirability biases in responses. Finally, at the time the focus group was conducted, the pulmonary clinic had recently transitioned from paper medical charts to an EHR. However, the stand-alone spirometry instrument could not communicate with their EHR. Thus, the implication of the selected quote highlights the excitement for improvements in office workflow and efficiency in asthma care.

The perceived usefulness of the mHealth technology among pediatric primary care clinicians and pulmonologists practicing in Hartford, CT, is in agreement with several studies that have investigated the effectiveness, feasibility, and acceptability of mHealth asthma apps [13,15,25–31]. MHealth technology has the potential to enhance patients' adherence to asthma therapy and improve asthma control and self-management through the provision of educational coaching [18], yet major gaps still exist. Reportedly, 75% of children aged 8 years and younger have access to a mobile device [32]; thus, the potential impact and reach for improving asthma outcomes with a sensor-based and evidence-based mobile technology are significant. There is moderate quality evidence that individuals with asthma receiving a text messaging intervention experienced greater improvements in peak expiratory flow and asthma symptoms compared to controls [33]. More concerning is the lack of reliable, evidence-based asthma apps that provide safe and accurate information on asthma [34]. Most notable is the lack of evidence on the effectiveness of sensor-based mHealth asthma technology. Yet, data from the tech wearables industry suggest failure in keeping the interest of users long term, where a third of users stop using the device within six months of receiving it [35]. Thus, sustainability of the long-term use of mobile technology will require further understanding of the science of behavior change and characterization of how clinicians and their patients integrate such technology into clinical workflow and disease management.

Our understanding of the perceived usefulness of an mHealth app- and sensor-based technology among clinicians evolved during the course of this study. Although initially we predicted that all clinicians would positively welcome the usefulness of inter-visit lung function data via the mobile spirometer, it became clear that this feature was not appealing primarily because the pediatricians

Downloaded by [University of Liverpool] at 07:28 13 October 2017

were not currently using spirometry in their practice setting. In addition, we did not anticipate the resounding agreement in the benefit of the technology to provide continuity of care in the school setting.

Conclusions/key findings

This study addresses and fills a gap in knowledge by providing not often sought insight into clinician's attitudes toward the usefulness of a mobile health asthma app and technology. A key benefit of the Cohero mHealth platform is the ability to obtain real-time adherence data that can be pushed directly into a clinicians' EHR. Data can be viewed either during a scheduled clinic visit or after a customizable, patient-specific threshold has been met. This was seen as an added-value to the clinician's provision of high-quality asthma care. The ability of the mHealth app to collect, store, and display long-term data of seasonal patient and practice trends was viewed as an educational tool that could inform quality improvement efforts. Concerns about the risk of data accuracy due to families presumed inhaler-sharing practices, and protecting patient privacy warrants further investigation in order to understand how systems can best be used to enhance asthma management.

Declaration of interest

Dr. Manice is the CEO and Co-founder of Cohero Health. Ms. Cushing is a full time medical student and part-time Clinical Project Manager for Cohero Health. Ms. Melvin is a Product Development Summer Associate for Cohero Health. Ms. McGowan is a Research Associate for Cohero Health. Dr. Hollenbach reports no financial support from Cohero Health. The relationship the corresponding author has with the Cohero Health entity is solely comprised of furthering the scientific understanding of the technology developed by Cohero Health. Dr. Hollenbach received no financial support from Cohero Health to conduct the studies outlined in this manuscript. Funds to conduct this study came from the Connecticut Children's Medical Center's Department of Research in the form of salary to support Dr. Hollenbach's research efforts in advancing the understanding and management of pediatric asthma. The sole purpose of having the CEO and Co-Founder of Cohero Health, Dr. Melissa Manice, present during the focus groups was to provide an expert overview of the mobile health app and technology on which the participants were to provide their perceptions and feedback. Dr. Manice did not participate as a facilitator of the focus groups, except for the sole purpose of answering questions regarding the technical capabilities of the product being discussed. Cohero Health did not provide any financial support for the facilitators to conduct the study.

References

1. Bloom B, Cohen RA, Freeman G. Summary health statistics for U.S. children: National Health Interview Survey, 2011. In: Statistics NCfH, ed. Washington, DC: Vital Health Stat; 2012.
2. Sarpong EMaMGE. Changes in Children's Use and Expenditures of Asthma Medications, United States, 1997–1998 and 2007–2008. Statistical Brief #341. In: Quality AfHRa, editor. Rockville, MD 2011.
3. Lasmar L, Camargos P, Champs NS, Fonseca MT, Fontes MJ, Ibiapina C, et al. Adherence rate to inhaled corticosteroids and their impact on asthma control. Allergy. 2009;64(5):784–789.
4. Claxton AJ, Cramer J, Pierce C. A systematic review of the associations between dose regimens and medication compliance. Clin Ther. 2001;23(8):1296–1310.
5. McQuaid EL, Kopel SJ, Klein RB, Fritz GK. Medication adherence in pediatric asthma: reasoning, responsibility, and behavior. J Pediatr Psychol. 2003;28(5):323–333.
6. Einarson TR. Drug-related hospital admissions. The Annals of pharmacotherapy. 1993;27(7–8):832–840.
7. Petrie KJ, Perry K, Broadbent E, Weinman J. A text message programme designed to modify patients' illness and treatment beliefs improves self-reported adherence to asthma preventer medication. Br J Health Psychol. 2012;17(1):74–84.
8. McQuaid EL, Everhart RS, Seifer R, Kopel SJ, Mitchell DK, Klein RB, et al. Medication adherence among Latino and non-Latino white children with asthma. Pediatrics. 2012;129(6):e1404–10.
9. Barnett SB, Nurmagambetov TA. Costs of asthma in the United States: 2002–2007. The Journal of allergy and clinical immunology. 2011;127(1):145–152.
10. Stern L, Berman J, Lumry W, Katz L, Wang L, Rosenblatt L, et al. Medication compliance and disease exacerbation in patients with asthma: a retrospective study of managed care data. Ann Allergy Asthma Immunol. 2006;97(3):402–408.
11. McGrady ME, Hommel KA. Medication adherence and health care utilization in pediatric chronic illness: a systematic review. Pediatrics. 2013;132(4):730–740.
12. Bender BG, Rand C. Medication non-adherence and asthma treatment cost. Curr Opin Allergy Clin Immunol. 2004;4(3):191–195.
13. Chapman KR, Walker L, Cluley S, Fabbri L. Improving patient compliance with asthma therapy. Respir Med. 2000;94(1):2–9.
14. Lenhart A. Teens, Smartphones, and Texting Pew Research Center2012 [Available from: http://www.pewinternet.org/2011/06/16/social-networking-sites-and-our-lives/
15. Singh A, Wilkinson S, Braganza S. Smartphones and pediatric apps to mobilize the medical home. J Pediatr. 2014;165(3):606–610.
16. Bender B, Wamboldt FS, O'Connor SL, Rand C, Szefler S, Milgrom H, et al. Measurement of children's asthma medication adherence by self report, mother report, canister weight, and Doser CT. Ann Allergy Asthma Immunol. 2000;85(5):416–421.
17. Milgrom H, Bender B, Ackerson L, Bowry P, Smith B, Rand C. Noncompliance and treatment failure in children with asthma. The Journal of allergy and clinical immunology. 1996;98(6 Pt 1):1051–1057.
18. Huang X, Matricardi PM. Allergy and Asthma Care in the Mobile Phone Era. Clin Rev Allergy Immunol. 2016.

Downloaded by [University of Liverpool] at 07:28 13 October 2017

19. Charles T, Quinn D, Weatherall M, Aldington S, Beasley R, Holt S. An audiovisual reminder function improves adherence with inhaled corticosteroid therapy in asthma. J Allergy Clin Immunol. 2007;119(4):811–816.
20. Cook KA, Modena BD, Simon RA. Improvement in asthma control using a minimally burdensome and proactive smartphone application. J Allergy Clin Immunol Pract. 2016.
21. 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(3):210–219.
22. Pinnock H, Slack R, Pagliari C, Price D, Sheikh A. Understanding the potential role of mobile phone-based monitoring on asthma self-management: qualitative study. Clin Exp Allergy. 2007;37(5):794–802.
23. Morgan DL. KR. The Focus Group Kit. Sage Publications; 1998.
24. Krueger RA. Analyzing & Reporting Focus Group Results. Sage Publications; 1998;Focus Group Kit(6).
25. Tran N, Fau CJ, Fau SK, Cabana M. Patient reminder systems and asthma medication adherence: a systematic review. J Asthma. 2014;51(5):536–543.
26. Rifaat N, Abdel-Hady E, Hasan AA. The golden factor in adherence to inhaled corticosteroid in asthma patients. Egypt J Chest Dis Tuberculosis. 2013;62(3):371–376.
27. Farooqui N, Phillips G, Barrett C, Stukus D. Acceptability of an interactive asthma management mobile health application for children and adolescents. Ann Allergy Asthma Immunol. 2015;114(6):527–9.
28. Liu WT, Huang CD, Wang CH, Lee KY, Lin SM, Kuo HP. A mobile telephone-based interactive self-care system improves asthma control. Eur Respir J. 2011;37(2):310–317.
29. Licskai C, Sands TW, Ferrone M. Development and pilot testing of a mobile health solution for asthma self-management: asthma action plan smartphone application pilot study. Can Respir J. 2013;20(4):301–306.
30. Lucas RW, Dees J, Reynolds R, Rhodes B, Hendershot RW. Cloud-computing and smartphones: tools for improving asthma management and understanding environmental triggers. Ann Allergy Asthma Immunol. 2015;114(5):431–432.
31. Mosnaim G, Li H, Martin M, Richardson D, Belice PJ, Avery E, et al. A tailored mobile health intervention to improve adherence and asthma control in minority adolescents. J Allergy Clin Immunol Pract. 2015;3(2):288–90 e1.
32. Rideout, V., Saphir, M, Pai, S., Rudd, A., and Pritchett, J. https://www.commonsensemedia.org/research/zero-to-eight-childrens-media-use-in-america. [last accessed 28 October 2013]. Common Sense Media.
33. de Jongh T, Gurol-Urganci I Fau - Vodopivec-Jamsek V, Vodopivec-Jamsek V Fau - Car J, Car J Fau - Atun R, Atun R. Mobile phone messaging for facilitating self-management of long-term illnesses. Cochrane Database Syst Rev. 2012;1469–493X (Electronic)).
34. Huckvale K, Car M, Morrison C, Car J. Apps for asthma self-management: a systematic assessment of content and tools. BMC Med. 2012;10:144.
35. <Endeavour-Partners-Wearables-and-the-Science-of-Human-Behavior-Change-Part-1-January-20141.pdf>.

Downloaded by [University of Liverpool] at 07:28 13 October 2017