

Supplementary Appendix A: Asthma Control Measure (ACM) questions (modified from monthly to weekly)

- 1) How often did you have an asthma attack **in the past week?**
 - a. Not at all
 - b. Once or twice
 - c. 3 to 6 times
 - d. Once a day
 - e. More than once a day
- 2) How often have you been awakened at night because of your asthma symptoms **in the past week?**
 - a. Never
 - b. Once
 - c. Twice
 - d. Three or more times but not every night
 - e. Every night

- 3) How much did your asthma interfere with your normal activities **in the past week?**
 - a. Not at all
 - b. A little
 - c. A moderate amount
 - d. A lot
- 4) How often have you used a rescue inhaler that gives quick relief from asthma symptoms **in the past week?**
 - a. Never
 - b. Once
 - c. 2 or more times but not daily
 - d. Daily
 - e. Several times a day, most days
- 5) How often did you have shortness of breath **in the past week?**
 - a. Not at all
 - b. Once or twice
 - c. 3 to 6 times
 - d. Once a day
 - e. More than once a day

Supplementary Appendix B: Screenshots

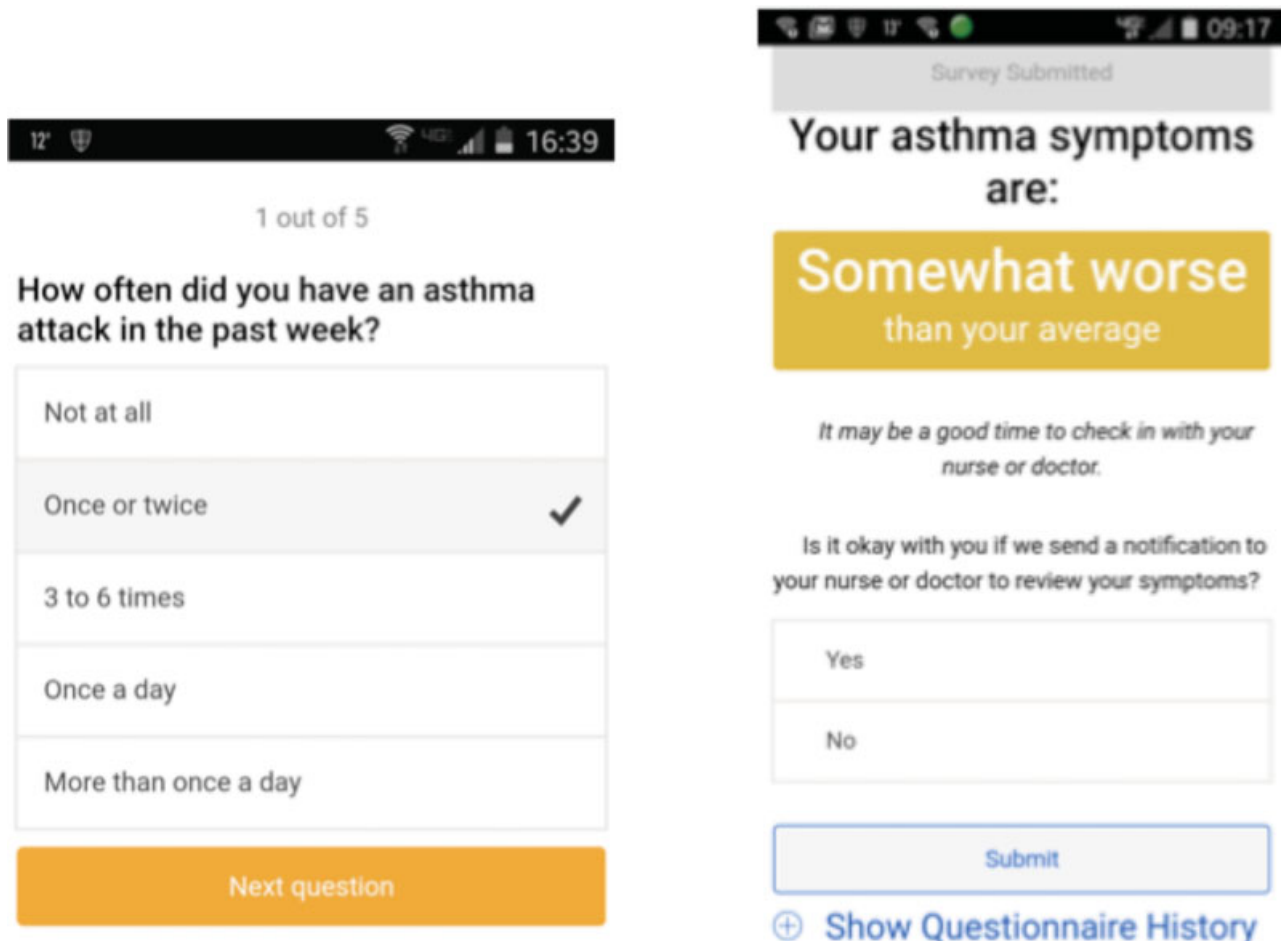


Fig. B1 Question 1 and example completion page.

BWH Admin Logout

PATIENTS Home / Patients

Rows on page: 10

[Add Participant](#)

#	First Name	Last Name	Username	Email	MRN	Status	Notifications	
	<input type="text" value="Search First Name"/>	<input type="text" value="Search Last Name"/>	<input type="text" value="Search Username"/>	<input type="text" value="Search Email"/>				
11	Laura	Shanahan	laurash	laurash@gmail.com	915781	active		View Profile
12	Paulo	Ramirez	pramirez	pauloramirez@harvard.edu	854197	active		View Profile
13	John	Doe	johndoe	johndoe@yahoo.com	5849732	active		View Profile
14	Kavita	Keren	kkeren	kavita@keren.com	4587921	active		View Profile
15	Molly	Mulcahy	mulchly	mollymulcahy@mass.gov	1584794123	active	!	View Profile
16	Vinnie	Dortenzio	vdortenzio	vdortenzio523@msn.com	49583346	active	!	View Profile
17	Bella	Olson	bolson	bella1938@aol.com	92543184	active		View Profile
18	Rachel	Christensen	rachelc	christensen@partners.org	6852541	active	!	View Profile
19	Theodore	Blakeley	tblakeley	ted@tedblakely.com	29761853	active	!	View Profile
20	Scott	Wiesnewski	scottski	scottski@tumbullprice.com	736951	active		View Profile

1 2 3 4

Fig. B2 Care manager view (data are fictional).

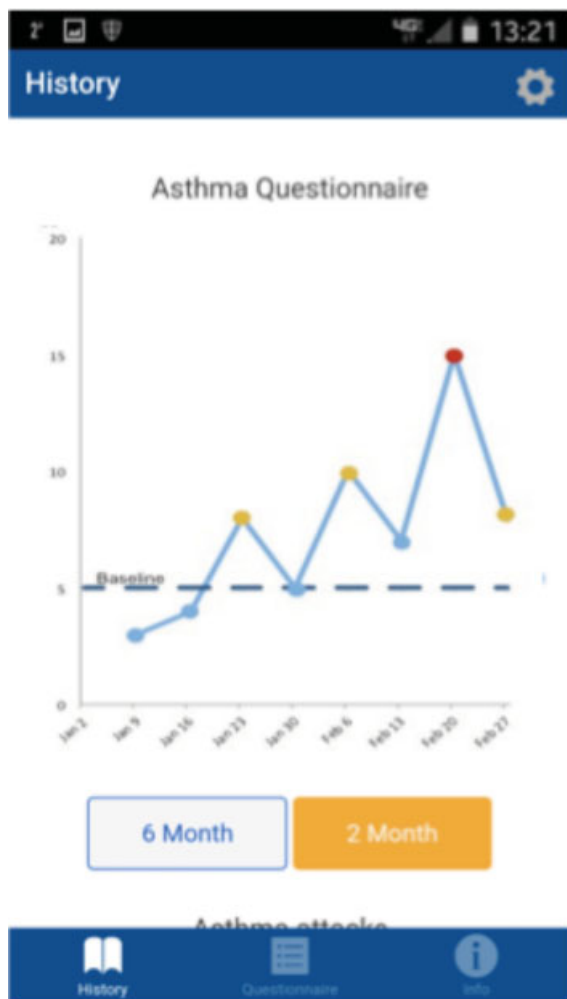


Fig. B3 Patient view of symptom graph (data are fictional).

Supplementary Appendix C: Interview guides

Patient

1. Tell me about your experience with the asthma app. How did it go?
 - a. Probe: What did you like about it?
 - b. Probe: What did you dislike?
 - c. Probe: Was your asthma control better or worse because of the app? If so, how?
 - d. Probe: What would have made it more useful for you?
 - e. Probe: What benefits were you hoping to have from this study? Why did you agree to participate?

Now, I'd like to ask you some specifics about each of the app's features.

2. Set up and invitation.
 - a. Did you have any challenges installing the app or setting it up?
 - b. At the beginning of the study, you entered your baseline symptoms. How did that go? Was it challenging? Did you think your baseline should have been changed during the study at all?
3. Weekly questionnaires.
 - a. How often did you fill out the weekly questionnaires?
 - b. Did you miss any weeks? If so, why? What would have helped to make sure you filled them out?
 - c. Were the weekly prompts too frequent? Not frequent enough?
 - d. The prompts arrived every week at 9am and then there was a reminder every 12 hours. Would you have preferred different timing?
 - e. The prompts gave you 48 hours. What did you think about that deadline?
 - f. Did you have any barriers to filling out the questionnaires? Was the 5-digit PIN a barrier?
4. Notifications and call from nurse.
 - a. How often did you receive a call from the nurse? What kinds of things did you discuss? Were they helpful for you in managing your asthma? If so, how?
 - b. For these calls, did you request them yourself? Were any automatically requested? Which did you prefer?
 - c. Did you always receive a call when you expected to receive one? Were any calls unexpected?
 - d. Did you ever receive calls 2 weeks in a row or more? Was the second week call more or less useful compared with the first?
5. Symptom history graph.
 - a. Did you ever check your symptom history? If so, how often? Was it helpful to you? If so, how?
 - b. Were the graphs clear? Did you have difficulty with interpreting them?
6. In-person visits and discussions with physician.
 - a. Did using the app impact your interaction with your physician? If so, how?

- b. Did you ever discuss the data in the app with your physician? If so, how did the conversation go?
- c. Did the physician ever bring up your symptoms recorded in the app? Did you ever bring them up with the physician?

7. Wrapping up.
 - a. Did you seek help for your asthma outside of the app process? E.g. Did you call the doctor directly or go to the ED? If so, please describe what happened.
 - b. If the app was still available after this research project, would you continue to use it?
 - c. Would you recommend this app to others who have asthma? Why or why not?
 - d. What could have made this app better for you? Or more likely that you would use it? What other features would you recommend?
 - e. Would you prefer any configuration options?
 - f. Do you have any other thoughts you would like to share about this app?

Physician

- 1) What did you think of the intervention overall?
 - a. Probe: What did you like about it?
 - b. Probe: What did you dislike about it?
 - c. Probe: Did it affect your experience with your patients? If so, how?
 - d. Probe: Did it add more work for you? Remove any work?
 - e. Probe: What would have made it more useful?

Now, I'd like to ask you some specifics.

- 2) Invitation. What did you think of the invitation process?
 - a. Did you have difficulty selecting patients who might benefit?
 - b. Were there any challenges with the process of using a letter to the patient signed by you?
- 3) Interaction with care manager. Did the nurse contact you about any patients because of their reported symptoms?
 - a. What happened during that interaction?
 - b. Did you think it was clinically appropriate for you to be contacted?
 - c. Do you think it benefited patients? If so, how?
 - d. Were there any challenges or problems with this process? Do you have suggestions for improving it?
- 4) During visits. Was there anything different about the visits with study patients?
 - a. Did you notice the PRO data in the EHR? If not, what could we have done to make sure you noticed it? Would it have been helpful?
 - b. Did you discuss the app or the data with any patients? If so, how did the conversation go?
 - c. Did the PRO information influence your thinking about how to treat any patients? Did you make any changes based on the information?

- d. What might have helped you make better use of the PRO data during visits?
- 5) Wrapping up.
- Do you have any other feedback about the app or intervention?
 - What would you recommend we change to make it better?
 - Would you participate if it were offered after study completion?

Nurse

- What did you think of the intervention overall?
 - Probe: What did you like about it?
 - Probe: What did you dislike about it?
- Dashboard. What did you think of the dashboard?
 - What did you like about it? Dislike about it?
 - What are some opportunities for improvement?
- Weekly workload.
 - How many patients did you call each week? How much time did you spend per call?
 - What did you discuss with the patients when you called them?
 - How was the call typically resolved?
 - Did you ever need to communicate with the patient's physician? How often? Please describe the process. What did you talk about with the physicians?
 - You received an email whenever a patient requested a call. Did you rely on these emails to remind you to check the dashboard?
- Putting data in the EHR.
 - You pasted the PRO data in the EHR before each patient's visit. How many times did you do that per week? How long did it take each time?
- Wrapping up.
 - Do you have any other feedback about the intervention?
 - What would you recommend we change to make it better?

Supplementary Appendix D: Usability assessment

Table D.1 System Usability Scale scores from patients completing the study

System Usability Scale Performance ¹ N = 11	Mean	(SD)
System Usability Score	88.9	(13.8)
	N	(%)
Patients awarding perfect score	5	(45%)

¹The System Usability Scale is a validated ten-item user instrument to measure an applications usability. The scale ranges from 0 to 100 whereby 100 is perfect high score.

Supplementary Appendix E: Analyses of post-study period data

Due to a software bug, 23 patients who completed the 6 months study period continued to receive notifications on their phone to complete weekly questionnaires until we shut down the study. (We disabled the notifications at 6-months but the software continued to send them.) We report some additional data and analyses of these patients. This additional usage suggests that the intervention had value to many study patients.

Table E.1 Post-study period mHealth app utilization

N = 23 (patients eligible to use app in post-study period)		Mean	(SD)
% Questionnaire completion		57%	(38)
		N	(%)
Patients completing at least one questionnaire		20	(87%)
	N	Percent Questionnaires Complete	T-test P-value
Categorical Variables		Mean	(SD)
Gender			
Male	6	48	44
Female	17	60	37
Education			
Bachelors+	13	66	34
No Bachelors	7	42	43
Missing (excluded from analysis)	3		
Ethnicity/Race			
White	17	57	41
Non-white	6	55	32