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Luzmercy Perez, BA, Knashawn H. Morales, ScD, Heather Klusaritz, PhD, MSW, Xiaoyan Han, MS, Jingru Huang, BA, Marisa Rogers, MD, MPH, Ian M. Bennett, MD, PhD, Cynthia S. Rand, PhD, Grace Ndicu, AS, Andrea J. Apter, MD, MSc, MA

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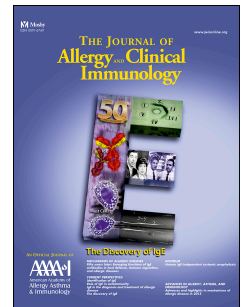
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A Healthcare Navigation Tool Assesses Asthma Self-Management and Health Literacy

Luzmercy Perez, BA^{1,2}

Knashawn H. Morales, ScD^{2,3}

Heather Klusaritz, PhD, MSW^{2,4}

Xiaoyan Han, MS^{2,3}

Jingru Huang, BA^{1,2}

Marisa Rogers MD, MPH^{2,5}

Ian M. Bennett, MD, PhD⁶

Cynthia S. Rand, PhD⁷

Grace Ndicu, AS^{1,2}

Andrea J. Apter, MD, MSc, MA^{1,2}

¹Division of Pulmonary Allergy Critical Care Medicine, ²Perelman School of Medicine, University of Pennsylvania, ³Department of Biostatistics and Epidemiology, ⁴Department of Family Medicine and Community Health, ⁵Division of General Internal Medicine, ⁶Departments of Family Medicine & Psychiatry and Behavioral Sciences, University of Washington, Box 354696, Seattle WA 98195-4696, ⁷Division of Pulmonary and Critical Care Medicine, Johns Hopkins School of Medicine, Baltimore, Maryland

Corresponding author:

Andrea J. Apter, MD, MSc, MA
829 Gates Building
Hospital of the University of Pennsylvania
3600 Spruce Street
Philadelphia, PA 19104.
Telephone: (215) 662-2425
FAX: (215) 615-0780
apter@mail.med.upenn.edu

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ABSTRACT

BACKGROUND: Self-management of moderate/severe asthma depends upon patients' ability to: 1) navigate (access health care to obtain diagnoses and treatment), 2) use inhaled corticosteroids (ICS) properly, and 3) understand ICS function.

OBJECTIVE: To test whether navigation skills (medication recall, knowledge of copay requirements ability to provide information needed for a medical visit about a persistent cough unresponsive to medication), are related to other self-management skills and to health literacy.

METHODS: A 21-item Navigating Ability (NAV2) questionnaire was developed, validated, then read to adults with moderate/severe asthma. ICS technique was evaluated by scales derived from instructions in national guidelines; knowledge of ICS function by a validated 10-item questionnaire. Spearman correlation was computed between NAV2 score and these questionnaires and with numeracy (Asthma Numeracy Questionnaire) and print literacy (Short Test of Functional Health Literacy in Adults).

RESULTS: 250 adults participated: age 51 ± 13 years, 72% female, 65% African-American, 10% Latino, 50% with less than \$30,000 household income per year, 47% with no more than a 12th grade education, 29% experienced hospitalizations for asthma in the prior year. Higher NAV2 score was associated with correct ICS technique ($p=0.24$, $p=0.0002$), knowledge of ICS ($p=0.35$, $p<0.001$), better print literacy ($p=0.44$, $p<0.001$) and numeracy ($p=0.41$, $p<0.001$).

CONCLUSIONS: Patients with poor navigating ability are likely to have poor inhaler technique and limited understanding of ICS function, as well as limited numeracy and print literacy. Clinicians should consider these elements of self-management for their impact on asthma care and as a marker of more general health literacy deficits.

CLINICAL IMPLICATIONS

Patients' healthcare navigation ability predicts patients' asthma self-management skills and more generally their health literacy. Attention to navigation may allow providers to tailor information and ultimately improve patient-provider communication.

66 **CAPSULE SUMMARY**

67 A healthcare navigation ability tool was developed and validated. Navigation ability is positively
68 associated with proper inhaler technique, knowledge of inhaler function and health literacy.
69 Clinicians can use this tool to assess patients' self-management skills.

70 **KEY WORDS**

71 Adults

72 Asthma

73 Health disparities

74 Health literacy

75 Inhaled corticosteroids

76 Minority groups

77 Numeracy

78 Print literacy

79 Self-management

80

81 ABBREVIATIONS

82 ACQ: Asthma Control Questionnaire

83 ANQ: Asthma Numeracy Questionnaire

84 BMI: body mass index

85 DPI: dry powder inhaler

86 ED: Emergency Department

87 FEV-1: forced expiratory volume in 1 second

88 ICS: inhaled corticosteroid

89 MDI: metered dose inhaler

90 MiniAQLQ: Mini-Asthma Quality of Life Questionnaire

91 NAV2: Navigating Ability 2

92 S-TOFHLA: Short Test of Functional Health Literacy in Adults

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94

INTRODUCTION

Self-management of moderate/severe asthma depends upon patients' ability to: access healthcare, or navigate. Navigation, a concept first introduced in management of cancer, is the facilitation of activities that allow early diagnosis and treatment.¹⁻³ The growing body of evidence supporting navigation as an effective intervention to improve screening and access to care in oncology has more recently been applied to chronic diseases such as diabetes,⁴ hypertension,⁵ and depression.⁶ Navigation has not yet been investigated in asthma. Navigation tasks might include successful medication recall, understanding copay and insurance requirements for medical visits, and knowing how to organize and respond to provider recommendations. Navigation and other self-management skills like proper use of ICS and understanding their function depend upon health literacy.

Half of US adults have no more than basic reading and numerical skills.⁷ Patients who have limited literacy skills have greater difficulty accessing healthcare and navigating complex health systems and associated clinical practices.^{8,9} Low health literacy, which includes reading comprehension (or print literacy) in the health context, is associated with poor self-management of chronic diseases, including asthma.^{10,11} Another health literacy component that contributes to self-management is numeracy, which includes basic arithmetic skills, in addition to health management tasks like timing medications and scheduling appointments.^{12,13} Numeracy also includes higher level concepts like estimation, probability, problem-solving, understanding variability and error in measurement, and risk assessment.^{12,14-16} All of these numerical skills are used in asthma management to understand the risk of uncontrolled disease compared to its management and to navigate healthcare resources by patients.^{15,17} Limited numerical skills were found to be associated with increased asthma-related hospitalizations and Emergency

Department (ED) visits, lower asthma-related quality of life, and reduced asthma control.^{12,13,18}
Thus, identifying patients with low literacy and developing effective interventions are needed.

However, screening patients in a medical encounter for low print literacy or numeracy may be anxiety-provoking, embarrassing, and deter patient-provider communication.¹⁹⁻²¹ If questions about navigating or accessing healthcare are also associated with validated health literacy tools, these navigation questions can serve as proxies for measuring print literacy and numeracy without embarrassing the patient while also evaluating essential patient navigation skills. Asthma care questions may also be more readily integrated into the flow of conversation between a provider and patient in a clinic visit than the administration of a literacy tool.⁸ Patients that are identified as at risk for low health literacy could prompt the use of simpler language in clinical interviews and the “teach back” technique, asking patients to repeat instructions to confirm understanding.²² By correlating different self-management skills like navigation or knowledge of essential functions of inhaled corticosteroids, or proper use of a corticosteroid-containing inhaler, the assessment of one can inform the likelihood of difficulty with other skills. In the current study we report the 1) development and validation of a questionnaire called the NAV2 that focuses on assessing asthma navigation skills, 2) examination of the association of navigation scores with other essential self-management tasks (patients’ knowledge of the function of inhaled corticosteroids (ICS) and ability to correctly use their corticosteroid containing inhaler), and 3) comparison of results from these self-management assessments with numeracy and print literacy scores. We hypothesize that navigation score will be positively associated with patients’ knowledge of the function of ICS and ability to correctly use these inhalers and that better self-management assessments will be positively associated with higher health literacy.

METHODS

Study Design and Questionnaire Development

We employed an exploratory mixed methods approach including questionnaire development²³ and a cross-sectional analysis of baseline data that is nested within an ongoing randomized controlled trial, A Patient Advocate to Improve Real-world Asthma Management for Adults Living in the Inner-city (NCT01972308, R18 HL116285). The parent study compares an individualized patient advocate intervention to currently practiced, guideline-based usual care in adults with moderate or severe asthma. Approval for this research was obtained from the Institutional Review Board of the University of Pennsylvania.

Participants

Patients 18 years and older with a physician's diagnosis of asthma and prescribed an inhaled corticosteroid were identified by the electronic health records of participating practices. The practices included outpatient primary care and asthma specialty practices within the University of Pennsylvania Health System, a federally qualified health center, and a primary care practice serving mainly Spanish-speaking patients.

Identified patients were invited for screening for evidence of reversible airflow obstruction: a FEV-1 less than 80% predicted at the time of screening or within the 3 years prior to this screening, and improvement with bronchodilator. For the parent study, participants were randomized to work with a patient advocate or to usual care. Exclusion criteria included inability to complete study tasks due to severe psychiatric or cognitive issues, difficulty understanding and providing informed consent, or inability to communicate in English or Spanish.

Procedures

After providing informed consent, participants completed questionnaires about their asthma history, current asthma status, quality of life, socio-demographics, health literacy, and navigating ability. Spirometry was performed according to American Thoracic Society guidelines.²⁴

Navigating Ability Questionnaire Development

In order to develop a questionnaire to measure patient navigation ability, we followed procedures described by Streiner and Norman,²⁵ Collingridge,²⁶ and McKinley et al.²⁷ First, we reviewed the oncology navigation literature which included well-established categories of navigation such as insurance, referrals, community resources, and transportation access.^{25,26} Next, we convened focus groups of patients and providers to inform the design of the ongoing patient advocate study. Participants in both groups were diverse in terms of race/ethnicity and sex. Patients also were diverse with respect to asthma severity, comorbidities, and social support. Healthcare providers were diverse according to practice (primary care versus asthma specialty) and years in practice. Focus groups discussions generated items for a draft of a navigation questionnaire.²⁸ Then, we piloted these questions about accessing healthcare for an outpatient appointment.^{28,29} These pilot participants were also diverse in terms of race/ethnicity, age, gender, asthma severity, comorbidities, and household income. The group was enriched for patients with the highest asthma morbidity: female low-income adults. Based on these experiences we refined the questionnaire and used it in the ongoing patient advocate study (Table 1). Many other factors likely influence navigation ability including personal factors such as empowerment, system factors such as ease of access and cultural factors. This study was not

designed to look at these influences, but future research is warranted on these potential influences.

The NAV2 questionnaire is comprised of 21 questions, which asks about medication recall, co-pay requirements, accessing health insurance, and the information needed in preparation for an outpatient visit. Each item has an individual score based on whether or not the response was correct. A total NAV2 score was the sum of items correct, range 0 to 21 (Table 1). A statistical analysis to validate the NAV2 is presented followed by a cross-sectional analysis examining the association between numeracy and print literacy and self-management skills for a chronic disease, asthma, examining participants at baseline of the parent study.

Other Self-management Measures

Inhaled Corticosteroid Knowledge

Inhaled corticosteroids are essential medications for all but intermittent asthma. We measured knowledge of ICS function using a previously validated 8-item questionnaire, with a 5-point response scale.^{30,31} Two additional items were added to this questionnaire. The scale is calculated by using a total score from the sum of the items, reversing items where needed so that a higher score indicates having more knowledge of the function of inhaled steroids. It has a range of 10 to 50. (e-Table 1)

Inhaler Corticosteroid Technique

Trained research coordinators observed and graded ICS inhaler technique using a 7-point scale for metered dose inhalers (MDIs) and a 6-point scale for dry powder inhalers (DPIs). The scales were derived from instructions in national guidelines.³² (e-Table 2)

Patient-perceived Asthma Severity

Asthma-related quality of life was measured with the Mini-Asthma Quality of Life Questionnaire (MiniAQLQ).³³⁻³⁵ Asthma control was assessed by the 7-item version of the Asthma Control Questionnaire (ACQ) which asks about symptoms over the past week.³⁶⁻³⁸

Health Literacy Variables

The health literacy questionnaires used are available in English and Spanish. To assess asthma-related numerical skills, the Asthma Numeracy Questionnaire (ANQ) was read to participants in their primary language while a written copy was available to view.¹² The ANQ is a validated 4-item questionnaire that tests numerical concepts, such as arithmetic and percentage, adapted from standard asthma education. The score is the number of correct answers with a range of 0 to 4.¹²

Reading comprehension was tested using the Short Test of Functional Health Literacy in Adults (S-TOFHLA) which consists of 36 modified Cloze procedure items.³⁹ The score is the number of items correct; however the authors recommend treating the score as a categorical variable which has functional relevance: inadequate (raw score ≤ 16), marginal (raw score of 17 to 22), and adequate (raw score of 23–36).^{40,41}

Other Participant Characteristics

The study sample was summarized according to self-reported demographic characteristics associated with literacy and asthma morbidity including age, race, ethnicity,

educational attainment, household income, insurance status, and comorbidities.^{8,42} Self-reported comorbidities were verified in the electronic health record in 10% of the sample.

Statistical Analysis

Descriptive statistics and data analyses were performed using STATA 14.1 (STATA Corporation, College Station, TX) and SAS 9.4 (SAS Corp, Cary, NC). The analysis proceeded in three phases. First, the internal consistency of the items and the reliability of the Navigating Ability scale were evaluated using Cronbach's alpha. In addition, the scale unidimensionality and item-person reliability was examined using a Rasch model and goodness of fit was assessed.²⁶

Secondly, Wilcoxon rank-sum tests were used to compare literacy (ANQ and S-TOFHLA scores) to each item of the Navigating Ability scale. To account for multiple testing, a false discovery rate approach was utilized.

Lastly, we examined the associations between literacy, self-management skills and navigating ability. For navigating ability we used the sum of items correct. Specifically, we assessed the association of literacy and self-management skills with navigating ability using Spearman correlation coefficients as the distributions of literacy, inhaler technique, and numeracy violated the assumption of normality. We confirmed the strength of the associations after adjusting for participant characteristics (educational attainment, household income, and race) using linear regression.

RESULTS

Recruitment

More than 80,000 records were reviewed and approximately 10,045 patients were identified who had an upcoming appointment, were at least 18 years with a physician's diagnosis of asthma and had an ICS prescription. After eliminating multiple appointments for any one patient; inadequate response to bronchodilator; and filtering for any severe psychiatric or cognitive problems and lung diseases such as pulmonary hypertension, cystic fibrosis and lung cancer; 2,265 patients were eligible. We made 534 attempts to contact potential participants by phone or in person and successfully reached 347. Two hundred and fifty patients agreed to participate and completed baseline surveys used in this analysis. Ninety-seven patients declined and gave the following reasons: 15 did not consider the parent study would be beneficial for them or others, 5 were concerned about research process and privacy issues, 19 had difficulty with travel time to get to appointments, 50 were too busy to participate, 3 had providers who believed the study to be not beneficial, and 5 stated they did not have asthma.

Participant characteristics

The 250 participants' age ranged from 19 to 85 years. Participants were mostly female and Black/African-American (Table 2). Almost half of the cohort had at least one asthma-related Emergency Department visit and almost one-third had been hospitalized for asthma in the past year. MiniAQLQ score was low and more variable than in the population of symptomatic asthmatics in which this measure was validated (4.0 ± 1.5 , compared with 5.4 ± 0.8).^{33,34} Asthma control scores tended to be in the uncontrolled range. Comorbidities were prevalent. The mean ICS knowledge score was 35 ± 6.7 , indicating low knowledge. Inhaler technique: 147 used an

MDI only; 95 a DPI only; 7 used both. Mean MDI score was for the 7 point questionnaire was 6.1 ± 1.0 , DPI score 5.6 ± 0.6 for the 6 point questionnaire.

NAV2 Validation

The Navigating Ability scale achieved moderate internal consistency with Cronbach's alpha 0.54 (item specific range 0.49-0.56). One- and two-parameter logistic Rasch models were fit to the navigating ability scale. The two-parameter model yielded significant improvement in the fit (likelihood ratio chi-square (df=20)=116.47, $p<0.001$) suggesting that the items have varying levels of discrimination. The overall goodness-of-fit test of the two-parameter Rasch model versus the saturated model found no evidence that the Rasch model does not hold ($p>0.99$). However, a model allowing multiple dimensions (Akaike Information Criterion (AIC)=5188.08) yielded a better fit compared to the unidimensional Rasch model (AIC=5245.84), suggesting the scale may be composed of more than one factor.

Item-level Analysis

More than two-thirds of participants answered correctly all medication recall items (items 1-4 of NAV2) and more than half answered correctly the co-pay requirement items (item 6 and 7) (Table 1). The follow-up medical visit question (item 10a) had the worst results with 8% providing the correct "prepares questions" response and 4% correctly responding "bring a family member or friend". There were significant associations between ANQ and 11 of 21 NAV2 items and S-TOFHLA and 9 of 21 NAV2 items after accounting for multiple testing as shown in Table 3. Participants that answered the NAV2 items correctly had higher levels of literacy as measured

by median ANQ and S-TOFHLA scores compared to participants with incorrect responses to NAV2 items.

NAV2 Score Association with Literacy and Other Self-management Questionnaires

NAV2 score is positively associated with numeracy (Spearman $\rho=0.41$, $p<0.001$) measured by the ANQ and reading comprehension ($\rho=0.44$, $p<0.001$), measured by the S-TOFHLA. NAV2 score was associated with other asthma self-management questionnaires: correct technique for using a corticosteroid-containing inhaler (0.24, $p=0.0002$) and inhaled corticosteroid knowledge (0.35, $p<0.001$). All associations remained statistically significant after adjusting for educational attainment, household income, and race.

DISCUSSION

We report the validation of a healthcare Navigation Ability tool, the NAV2, which is associated with health literacy measures of print and numeracy and also associated with other asthma self-management assessments. This association is important for patient care because it tells us that the navigation items, which are routine questions for asthma assessment, can be employed as indicators of the literacy skills of the patient, and also of knowledge of other essential concepts of self-management, without embarrassing patients or disrupting the flow of an office visit with a literacy screening questionnaire. Poor response to any of the navigating items associated with low literacy (Table 3) should prompt providers to spend more time educating the patient, simplifying information, or seeking additional resources to assist the patient. In addition, this knowledge can influence the number of follow-up tasks (behavior changes, medication changes, diagnostic testing and follow-up appointments) asked of patients. Prioritizing and limiting the number of such tasks may improve successful completion.

Potentially, three of the highest performing items (naming asthma medications, asking if a medication is controller or a reliever, and asking what is a co-pay) could be used quickly by a provider in an office visit to assess literacy and navigation skills. Further research is needed to see whether these three items together could serve as an effective brief screen for low literacy and poor navigation skills. This has potential implications for management of other chronic diseases given this population has significant comorbidities. Further research also is warranted to see whether modification of the quick screen could be used to identify patients with low literacy or poor navigation skills who have other chronic diseases such as hypertension or diabetes. It is noteworthy that our asthma study is important for being one of a very few studies that considers patients with prevalent comorbidities.

Our study has several limitations. First, this not a longitudinal study and does not demonstrate that an intervention to improve navigation improves subsequent health outcomes. Such a longitudinal study is an important next step. Nevertheless, the finding of reduced asthma control and asthma-related quality of life in our cohort tells us that populations with low healthcare navigating ability tend to be those with high asthma morbidity who need further intervention to achieve better control. Improving navigating ability or simplifying the navigations required of patients by practices needs evaluation. Second, our population is mostly from one health system and generalizability to other patient groups in other settings must be studied. However, this study draws patients from a number of diverse practices: family practice, general internal medicine, pulmonary, and allergy-immunology. In addition, the patients are generally from a group of patients with the highest asthma morbidity: minority women from low-income households. Even patients with high literacy have trouble navigating and remembering instructions in a stressful medical environment.¹⁷ While the generalizability would also improve if the NAV2 were modified for other chronic diseases, this could be done by modifying items 1-5.

In summary, simple navigation questions or questions about knowledge or proper use of inhaled corticosteroids also provide information about patient literacy and the need to match information to patient literacy needs.

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Table 1. Navigating Ability (NAV2) Questionnaire is displayed in the left-hand column. Scoring of each item is indicated in the shaded areas. The numbers of participants with correct response are presented in the right-hand column.

	Number of participants with correct response (N = 250)
1. Patient lists all asthma medication names correctly.	195 (78%)
2. Patient correctly recites number of times a day required to take inhaled steroid.	222 (89%)
3. Patient correctly recites number of puffs of inhaled steroid per unit of time.	215 (86%)
4. Patient can correctly name which of their medications is a controller and which is a reliever.	182 (73%)
5. Patient can recite action plan.	78 (31%)
The sum of “Yes” responses will be the score. Score range is 0 – 5. Score: _____	
6. Ask patient: “What is a co-pay?” Correct answer: A co-pay is the portion I pay for a medical visit or medication that insurance doesn’t cover. (Participant must indicate: I pay; not covered by insurance; for medical visit or medication or procedure) Correct answer: score 1. Incorrect or no answer: score 0. Score: _____	143 (57%)
7. Ask patient: “If you were unsure of the amount of your co-pay, what is the best way to find out how much it is?” Read choices and ask patient to choose the best response.	
a. Call the insurance company	167(67%)
b. Ask the receptionist	
c. Ask the doctor	
d. Ask a friend	
e. Other	
Correct answer: a. Call the insurance company: score 1. Incorrect or no answer: score 0. Score: _____	

8. Ask patient: "If your doctor prescribes a medicine that your health insurance does not cover, what would you do?"	
Read choices and ask patient to choose the best response.	
a. Call the doctor's office	197 (79%)
b. Wait until next visit, scheduled in a month	
c. Borrow from a friend or family member	
d. Do nothing	
e. Substitute another medicine	
Correct answer: a. Call the doctor's office: score 1. Incorrect or no answer: score 0. Score: _____	
9. Ask patient: "You are accompanying a friend to his/her first visit to a new primary care provider. Your friend was recently hospitalized. What would he/she need to bring to that visit?"	
Do not read options.	
a. Insurance card	148 (59%)
b. ID	105 (42%)
c. Medications/list of medications	127 (51%)
d. Records and/or test results	138 (55%)
The sum of "Yes" responses will be the score. Score range is 0-4. Score: _____	
10a. Ask patient: You were seen by the doctor for a cough. You were given a medication for the cough. The cough does not go away. You are going to a follow-up visit for the cough. What could you do to prepare for the visit?	
Do not read options.	
1. Write down or prepare questions	21 (8%)
2. Make a list of symptoms	54 (22%)
3. Know medications taken	65 (26%)
4. List problems with medications	51 (20%)
5. Other reasonable option: e.g., bring any tests or records since you had the initial visit	11(4%)
The sum of "Yes" responses will be the score. Score range is 0-5. Score: _____	
10b. Ask patient: "What could you do to remember the details of the visit?"	
Do not read options.	

1. Take notes at the visit	158 (63%)
2. Ask questions at the end of the visit	14 (6%)
3. Look at the visit summary	80 (32%)
4. Bring a family member or a friend	10 (4%)
The sum of "Yes" responses will be the score. Score range is 0-4. Score: _____	
Summary score (the sum from all questions): _____	
11. Patient can cogently report physician recommendations from their last visit. Not part of the summary score. Grade 1-5, with 5 being most cogent. Use 9 if no doctor's visit. Compare with instructions in electronic medical record when possible. Grade: _____	

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476 For items 1-5, 9-11, the response is: ☐₁ Yes ☐₀ No . The sum of the "yes" responses is the

477 score.

478 **Table 2.** Characteristics of 250 adults with moderate or severe asthma.

Characteristics	Total (N = 250)
Sociodemographics	
Age (y) [*]	51 ± 13
Female	181 (72%)
Race	
Black/African-American	162 (65%)
White	62 (25%)
Asian	3 (1%)
No response or declined to answer	22 (9%)
Ethnicity: Hispanic/Latino	24 (10%)
Household income per year	
< \$30,000	125 (50%)
\$30,000-\$49,999	35 (14%)
\$50,000-\$99,999	35 (14%)
\$100,000 or more	23 (9%)
No response or declined to answer	32 (13%)
Educational attainment (highest level achieved)	
8 th grade or less	3 (1%)
Some high school	31 (12%)
High school graduate	84 (34%)
Some college or trade school	61 (24%)
College graduate	71 (28%)
Health Insurance	
Medicaid	88 (35%)
Medicare only	58 (23%)
Self-pay (None)	3 (1%)
Commercial with or without Medicare	100 (40%)
No response or declined to answer	1 (1%)
Asthma severity	
FEV1 at enrollment (percent predicted) [*]	68 ± 19
No. with ≥ 1 ED visit for asthma in past year	104 (42%)
No. with ≥ 1 hospitalization for asthma in past year	73 (29%)
Asthma-related quality of life ^{*†}	4.0 ± 1.5
Asthma control ^{*††}	2.3 ± 1.2

Literacy	
Numeracy ^{*,§}	2.0 ± 1.3
Reading Comprehension (median IQR) ^{*,§§}	34 (25,35)
Co-morbidities (#)	
Hypertension	130 (52%)
Diabetes	53 (21%)
Body Mass Index (BMI) ^{*,**}	33.9 ± 8.9
Current smoker	44 (18%)
Ever smoked	128 (51%)

IQR = interquartile range

^{*} mean ± standard deviation

[†] Asthma-related quality of life was measured with the Mini-Asthma Quality of Life Questionnaire (MiniAQLQ). It is a 15-item questionnaire reflecting well-being over the past 2. It has a 7-point response scale for each item ranging from 1 (maximum impairment) to 7 (no impairment). The average of the items' scores yields the mean summary score.³³⁻³⁵

^{††} Asthma control was assessed by the 7-item version of the Asthma Control Questionnaire (ACQ).³⁶⁻³⁸ The score is the mean of all responses (0= total control, 6= extremely uncontrolled). A score of more than 1.5 is considered inadequate control.⁴³

[§] Numeracy was measured with the Asthma Numeracy Questionnaire.¹²

^{§§} Reading Comprehension was measured using the S-TOFHLA.³⁹ This distribution is highly skewed. We report median and interquartile range. 35 participants or 14% had inadequate literacy, 18 or 7% marginal literacy, 194 or 78% adequate and 3 or 1% missing on this measure.

^{**} Normal BMI is 18.5 to 24.9, overweight 25.0- 29.9, obese ≥ 30.

Table 3. The correlations of asthma numeracy (measured by the ANQ score) and print literacy (measured by the S-TOFHLA score) with navigating ability items among 250 patients with moderate or severe asthma. For example, a patient that does not know the names of asthma medications is more likely to have low numeracy and low reading comprehension.

NAV2 Items	ANQ [†]			S-TOFHLA		
	median (IQR) for NAV2 items: answered correctly	median (IQR) for NAV2 items: answered incorrectly	Unadjusted <i>p</i> -value	median (IQR) for NAV2 items: answered correctly	median (IQR) for NAV2 items: answered incorrectly	Unadjusted <i>p</i> -value
Medication and Action Plan Recall						
1: asthma medication names	2.0 (1.0-3.0)	1.0 (1.0-2.0)	0.001*	35 (30-35)	26 (17-35)	0.001*
2: frequency of ICS	2.0 (1.0-3.0)	2.0 (1.0-2.0)	0.016*	35 (25-35)	33 (21-35)	0.074
3: number of ICS puffs	2.0 (1.0-3.0)	1.0 (1.0-2.0)	0.009*	35 (26-35)	34 (17-35)	0.073
4: controller vs. reliever	2.0 (1.0-3.0)	1.0 (1.0-2.0)	<0.001*	35 (32-36)	26 (14-35)	<0.001*
5: asthma action plan	2.0 (1.0-3.0)	2.0 (1.0-3.0)	0.069	35 (32-36)	34 (23-35)	0.017*
Health Insurance Requirements						
6: co-pay requirements	2.0 (2.0-3.0)	1.5 (1.0-3.0)	<0.001*	35 (33-36)	32 (19-35)	<0.001*
7: co-pay amount	2.0 (1.0-3.0)	2.0 (1.0-3.0)	0.061	35 (29-36)	33 (19-35)	0.003*
8: no insurance coverage	2.0 (1.0-3.0)	1.5 (1.0-3.0)	0.059	35 (24-35)	34 (26-35)	0.197
Initial Medical Visit Preparation						
9a: insurance card	2.0 (1.0-3.0)	2.0 (1.0-3.0)	0.199	35 (29-35)	34 (20-35)	0.053
9b: ID	2.0 (1.0-3.0)	2.0 (1.0-3.0)	0.168	35 (28-35)	34 (23-35)	0.132
9c: list of medications	2.0 (1.0-3.0)	2.0 (1.0-3.0)	0.003*	35 (28-35)	34 (25-35)	0.195
9d: records and/or test results	2.0 (2.0-3.0)	1.0 (1.0-3.0)	<0.001*	35 (33-36)	32 (20-35)	<0.001*
Follow-up Medical Visit Preparation						
10a(1): questions	3.0 (2.0-4.0)	2.0 (1.0-3.0)	0.004*	35 (33-36)	34 (25-35)	0.093
10a(2): a list of Symptoms	3.0 (2.0-3.0)	2.0 (1.0-3.0)	0.001*	35 (34-36)	34 (21-35)	<0.001*

10a(3): know medications taken	2.0 (1.0-3.5)	2.0 (1.0-3.0)	0.053	35 (34-36)	34 (20-35)	0.002*
10a(4): list problems with Medications	2.0 (1.0-3.0)	2.0 (1.0-3.0)	0.122	34 (28-35)	34 (25-35)	0.199
10a(5): other reasonable option	2.0 (1.0-3.0)	2.0 (1.0-3.0)	0.199	35 (24-36)	34 (25-35)	0.060
Follow-up Medical Visit – Remember Details						
10b(1): take notes at the visit	2.0 (1.0-3.0)	2.0 (1.0-3.0)	0.003*	35 (31-36)	33 (18-35)	<0.001*
10b(2): ask questions at the end of the visit	1.0 (1.0-3.0)	2.0 (1.0-3.0)	0.109	34 (21-36)	34 (25-35)	0.199
10b(3): look at the visit summary	2.0 (1.0-3.0)	2.0 (1.0-3.0)	0.070	35 (31-35)	34 (23-35)	0.131
10b(4): bring a family member or a friend	4.0 (2.0-4.0)	2.0 (1.0-3.0)	0.012*	36 (35-36)	34 (25-35)	0.045

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500 IQR=interquartile range

501 * Statistically significant at 0.05 level after false discovery rate adjustment of Wilcoxon rank

502 sum p-values

503 †Asthma Numeracy Questionnaire, range 0-4¹²

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Supplementary Tables

Luzmercy Perez, BA^{1,2}

Knashawn Morales, ScD^{2,3}

Heather Klusaritz, PhD, MSW^{2,4}

Xiaoyan Han, MS^{2,3}

Jingru Huang, BA^{1,2}

Marisa Rogers MD, MPH^{2,5}

Ian M. Bennett, MD, PhD⁶

Cynthia S. Rand, PhD⁷

Grace Ndicu, AS^{1,2}

Andrea J. Apter, MD, MSc, MA^{1,2}

¹Division of Pulmonary Allergy Critical Care Medicine, ²Perelman School of Medicine, University of Pennsylvania, ³Department of Biostatistics and Epidemiology, ⁴Department of Family Medicine and Community Health, ⁵Division of General Internal Medicine, ⁶Departments of Family Medicine & Psychiatry and Behavioral Sciences, University of Washington, Box 354696, Seattle WA 98195-4696, ⁷Division of Pulmonary and Critical Care Medicine, Johns Hopkins School of Medicine, Baltimore, Maryland

Corresponding author:

Andrea J. Apter, MD, MSc, MA
829 Gates Building
Hospital of the University of Pennsylvania
3600 Spruce Street
Philadelphia, PA 19104.
Telephone: (215) 662-2425
FAX: (215) 615-0780
apter@mail.med.upenn.edu

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e-Table 1. Inhaled Corticosteroid Knowledge Questionnaire.^{1,2} The sum of the 5-point Likert score for each item is calculated so that more knowledge on an item results in a higher score.

	Definitely True	Mostly True	Don't Know	Mostly False	Definitely False
1. Inhaled steroids make airway muscles relax.	1	2	3	4	5
2. Inhaled steroids work by fighting inflammation.	5	4	3	2	1
3. Inhaled steroids work by fighting infection.	1	2	3	4	5
4. The full effect of inhaled steroids depends on regular use and may take days to work.	5	4	3	2	1
5. Inhaled steroids make you gain weight.	1	2	3	4	5
6. When you use inhaled steroids, your wheeze or chest tightness gets better immediately.	1	2	3	4	5
7. The full effect of inhaled steroids begins immediately.	1	2	3	4	5
8. Even if I have no symptoms from asthma, I should take [say rescue/reliever inhaler they are on] everyday so that I can stop asthma attacks from starting.	1	2	3	4	5
9. Even if I have no symptoms from asthma, I should take [say ICS they are on] everyday so that I can stop asthma attacks from starting.	5	4	3	2	1
10. [Say ICS they are on] should be taken only when I have asthma symptoms.	1	2	3	4	5

e-Table 2. Measure of Inhaler Corticosteroid Technique.³ For each, the score is the sum of the “yes” responses, so that a maximum score for MDI Inhaler Technique is 7, for DPI Inhaler Technique it is 6.

MDI Inhaler Technique	
1. Canister shaken	₁ Yes ₀ No
2. Exhales before actuating inhaler	₁ Yes ₀ No
3. Actuates inhaler at the start or within 1 second of the start of inhalation	₁ Yes ₀ No
4. Actuates only once per inhalation	₁ Yes ₀ No
5. Inhalation takes place over 3-5 seconds	₁ Yes ₀ No
6. Position of inhaler appears adequate	₁ Yes ₀ No
7. Patient holds breath for 6-10 seconds	₁ Yes ₀ No
DPI Inhaler Technique	
1. Exposes mouthpiece	₁ Yes ₀ No
2. Cocks the triggers (activates the diskus)	₁ Yes ₀ No
3. Holds diskus horizontally while inhaling	₁ Yes ₀ No
4. Inhales deeply	₁ Yes ₀ No
5. Holds breath 6 seconds	₁ Yes ₀ No
6. Does not blow into diskus	₁ Yes ₀ No

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