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Self-Management Behaviors among Older Adults with Asthma: Associations with Health Literacy

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Abstract

Background/Objectives: Older adults asthmatics experience high rates of morbidity and mortality yet little is known about their self-management behaviors. We examined self-management behaviors, including medication adherence and inhaler technique, among older adults and their association with health literacy.

Design: Observational cohort study.

Setting: Primary care and pulmonary specialty practices in two tertiary academic medical centers and three Federally Qualified Health Centers in New York City, NY and Chicago, IL.

Participants: Adults with moderate or severe persistent asthma, ages 60 years and older (n=433).

Measurements: Outcomes were adherence to asthma controller medications, metered dose inhaler (MDI) and dry powder inhaler (DPI) techniques, having a usual asthma physician, and

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Conflict of Interest

Dr. Wisnivesky is a member of the research board of EHE International, has received lecture fees from Novartis Pharmaceutical, consulting honorarium from UBC, and a research grant from GlaxoSmithKline.

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Study design: Alex D. Federman, Michael S. Wolf, Ethan A. Halm, Howard Leventhal, Juan P. Wisnivesky

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avoidance of four common triggers. Health literacy was assessed with the Short Test of Functional Health Literacy in Adults.

Results: The mean age was 67 years and 36% had marginal or low health literacy. Adherence was low (38%) overall and worse among individuals with low health literacy (22% vs. 47%, $p<0.0001$) and after adjusting for demographic factors and health status (odds ratio [OR] 0.48, 95% confidence [CI] 0.31-0.73). Similarly, inhaler technique was poor: only 38% and 54% had good MDI and DPI technique, respectively. Technique was worse among those with low health literacy (MDI technique: OR 0.57, 95% CI 0.38-0.85; DPI technique: OR 0.42, 95% CI 0.25 to 0.71). Asthma self-monitoring and avoidance of triggers occurred infrequently but were less consistently associated with low health literacy.

Conclusion: Adherence to medications and inhaler technique are poor among older asthmatics, and worse among those with low health literacy. Clinicians should routinely assess controller medication adherence and inhaler technique, and use low-literacy communication strategies to support self-management in older asthmatics.

Keywords

Asthma; elderly; self-management; adherence; inhaler technique; health literacy

INTRODUCTION

Persistent asthma is a chronic illness often characterized by periods of inactivity punctuated by acute flares. Exacerbations may lead to utilization of urgent care services such as emergency department visits and hospitalization, and occasionally death. Controlling asthma and preventing exacerbations requires meticulous attention to self-management,¹ including avoidance of triggers, such as cigarette smoke and allergens, regular monitoring by a healthcare provider, and consistent and proper use of daily anti-inflammatory controller medications.

Unfortunately, many patients fail to maintain adequate self-management behaviors. Although few studies have assessed it, asthma controller medication adherence appears to be particularly poor among older adults, with rates ranging from 9% to 21%.² Consistent with this observation, older asthmatics experience considerably higher rates of asthma-related urgent care use than and twice the mortality rate of middle-aged and younger asthmatics.^{3,4}

Low health literacy may be a contributor to poor adherence and poor health outcomes among older adults. The Institute of Medicine has defined health literacy as the degree to which individuals have the capacity to obtain, process, and understand basic information and services needed to make appropriate decisions regarding their health, and identifies it as a major contributor to poor illness self-management and poor health outcomes in general.⁵ However, only a small body of literature links low health literacy to asthma outcomes^{6,7} and even fewer studies have examined its impact on asthma self-management behaviors.⁸⁻¹⁰ The latter studies show small associations between health literacy and asthma inhaler technique but no association with medication adherence and none examine the association of health literacy with asthma trigger avoidance and self-monitoring behaviors. Furthermore, the

implications of the prior research is limited for older adults because the studies had small sample sizes and focused uniformly on non-elderly adults, in whom physical impairment could affect behaviors like inhaler technique.

Because low health literacy affects up to 60% of adults over age 65,¹¹⁻¹³ we sought to examine the role of health literacy in asthma self-management behaviors in this vulnerable, under-studied population. We specifically examined behaviors recommended by the 3rd Expert Panel Report for the diagnosis and management of asthma, including adherence to asthma controller medications, skill in the use of inhalers, asthma monitoring, and avoidance of asthma triggers.¹

METHODS

Patients and Settings

We conducted analyses of data from the Asthma Beliefs and Literacy in the Elderly (ABLE) study, a prospective cohort study of asthma in adults ages 60 years and older. The study began recruiting elderly asthmatics from outpatient clinics in New York City, NY and Chicago, IL in December 2009. The New York City practices are based at the Mount Sinai Medical Center, and include the general internal medicine, geriatrics primary care, and pulmonary practices, and an adult primary care practice of the Lutheran Family Health Services network of federally qualified health centers in Brooklyn, NY. The Chicago-based practices include the general internal medicine clinic of Northwestern University Hospital and the Mercy Health Clinic, a federally qualified health center. The study was approved by the Institutional Review Boards of the Mount Sinai School of Medicine, Lutheran Medical Center, and the Northwestern University Feinberg School of Medicine.

Potentially eligible asthmatics were identified by review of the electronic clinic encounter databases at each participating site. We enrolled patients ages 60 years and older who speak English or Spanish, and had uncontrolled asthma as defined by the National Heart, Lung and Blood Institute's Expert Panel on Asthma.¹⁴ We excluded individuals with a diagnosis of chronic obstructive pulmonary disease (COPD) or other chronic respiratory illness, as well as those with a smoking history of ≥10 pack-years because they are at increased risk of COPD. Trained, bilingual research assistants recruited patients by telephone. After obtaining verbal consent, the research assistants administered a brief screening assessment to determine final eligibility for the study. Eligible patients were then invited to undergo in-person interviews, in English or Spanish. Interviews were conducted at baseline, 3- and 12-months.

Outcome Measures

We assessed several measures of asthma self-management: adherence with controller medications, asthma inhaler technique, self-monitoring of asthma control, and avoidance of asthma triggers.

Medication Adherence—Subjective measurement of adherence to asthma controller medications (inhaled corticosteroids [ICS] and leukotriene receptor inhibitors [LTI]) was assessed with the Medication Adherence Reporting Scale (MARS). MARS is a validated,

10-item measure designed to minimize social desirability bias. It was previously adapted to assess adherence with asthma medications.¹⁵ Each item is rated on a 5-point Likert scale with higher scores indicating greater adherence. Participants with a MARS score of 4.5 were classified as having good adherence to controller medications.^{16,17}

We also assessed ICS adherence by reviewing the dose counters found on diskus inhaler devices among those patients using them. The diskus devices were reviewed by the research assistant during the first 3 months of study participation for each subject and 30 days after a new prescription was obtained. Good adherence was defined as 80% or more of expected doses recorded by the device.

Inhaler Technique—We examined patients' ability to administer their asthma controller medication therapies using a standardized checklist of steps in the proper use of a metered dose inhaler (MDI) and a dry powder inhaler (DPI). The MDI and DPI assessments addressed 8 and 7 steps in the use of the devices, respectively, covering the essential elements of use from preparation of the devices to their actuation and delivery of the medications.¹⁸⁻²⁰ During the in-person interview, the patient was asked to demonstrate use of the placebo devices. The MDI was administered to our entire sample regardless of their current asthma medication use, while the DPI was administered only to those who reported having a prescription for a DPI. Trained interviewers observed the patients and documented the number of steps correctly completed. We defined adequate inhaler technique for both type of devices as correct completion of all steps. We also conducted a sensitivity analysis in which we defined adequate technique as correct completion of 6 of 8 steps for the MDI and 5 or 7 steps for the DPI.

Preventive Measures and Self-Monitoring—Preventive measures, other than controller medication use, included avoidance of asthma triggers and other preventive measures taken to limit the impact of allergens. These included four yes-no items: (1) use allergy covers; (2) wash bed sheets in hot water; (3) have others clean up dust and mold in the home; and (4) whether a fur-bearing animal was kept in the home in the last 6 months. Three items assessed trigger avoidance as measured on a 5-point Likert scale (always, most of the time, sometimes, rarely, never): (5) windows kept closed in spring and summer; (6) smoking not allowed in the home; (7) general avoidance of fur-bearing animals.^{21,22} The latter three items were coded as always or most of the time versus other.

Self-monitoring measures included whether the patient reported having one doctor from whom she or he regularly received asthma care, whether they used a peak flow meter, and whether they had an asthma action plan.

Independent Variables—Health literacy was measured using the Short Test of Functional Health Literacy in Adults (S-TOFHLA).²³ The S-TOFHLA is composed of a 36-item reading comprehension section and a 4-item numeracy exercise. The reading comprehension section is presented as two timed (7-minute) clinically oriented reading passages that omit key words and phrases from sentences. The participant must select one of four response options listed under each section of missing text to correctly complete the sentence, both grammatically and contextually. The numeracy section assesses the patient's

ability to read and interpret information typically encountered in a healthcare setting. Scores range from 0 to 100, with higher scores indicating higher health literacy. We dichotomized health literacy as adequate (score ≥ 67) vs. marginal or low (score <67) following prior research.^{24,25} The S-TOFHLA correlates strongly with other measures of health literacy, has high internal consistency for the reading comprehension passages (Cronbach's alpha 0.97), and has been validated for use in both English and Spanish.²⁵

Other covariates were demographic indicators including age, sex, race/ethnicity, education, and income. We included measures of asthma history (number of years since diagnosis) since long-term experience with asthma and general health could affect asthma self-management behaviors. General health was measured using the single item general health measure from the Short-Form Health Survey.²⁶ Physical functioning was assessed with a measure of activities of daily living.²⁷

Statistical Analysis

We compared baseline characteristics of the sample by health literacy level (adequate vs. marginal or low, hereafter noted as adequate vs. low) using the chi-square test, student's t-test or Wilcoxon rank-sum test, as indicated. We modeled self-management behaviors with generalized estimating equation (GEE) models to account for clustering effects of repeated measures for study participants over time (baseline, 3- and 12-months), and controlled for the effects of demographic characteristics and asthma history. For models of inhaler technique, we also controlled for current use of an inhaler device (MDI or DPI) and deficiencies in activities of daily living since physical impairment could adversely affect the subject's ability to use a device. We used logistic regression to analyze ICS adherence data as measured by the diskus device because these data were only available at one time point. All analyses were performed with SAS statistical software (SAS Institute, Cary, NC).

RESULTS

We identified 1972 patients, successfully contacted 1506, and consented and screened 1025 of whom 502 were eligible. Of these, 452 completed the baseline interview. Nineteen participants (4.2%) had incomplete data on health literacy and were excluded from these analyses. Those missing health literacy data were more likely than those with complete data to have low levels of educational achievement ($p<.0001$), very low incomes ($p=.006$), and to report poor general health ($p=.02$). There were no differences by age, sex, race and ethnicity, use of asthma controller medications or history of intubation.

The sample included 433 individuals (Table 1). Follow up at 3- and 12-months were 97% and 84%, respectively. Of these, 39% were 65 to 74 years of age, and 16% were 75 and older at baseline. Study participants were mostly female (84%), and non-white (Hispanic, 39%, and black, non-Hispanic 31%). One-third (36%) of the sample had low health literacy. The mean number of years with asthma was 31 and 9% had a history of intubation. Asthma controller medications were used by 79% of subjects (73% reported using ICS either exclusively or in combination with leukotriene inhibitors, long acting beta agonists or another form of miscellaneous controller medication). Among those using inhaled

corticosteroids (n=316), 73% used a DPI, 25% used an MDI, and 2% used a different delivery device.

Adherence to Asthma Controller Medications

Only 38% of patients reported adequate adherence (Table 2). Low health literacy was significantly associated with low asthma controller medication adherence. At baseline, individuals with low health literacy had half the rate of adherence compared with those with adequate health literacy (22% vs. 47%, respectively; $p<0.0001$) (Table 2). Health literacy remained significantly associated with poor adherence in a series of GEE models that adjusted for age and sex, race and ethnicity, and number of years with asthma (odds ratio [OR] 0.48, 95% confidence interval [CI] 0.31-0.73) (Table 3). Both black race and Hispanic ethnicity were significantly associated with poor adherence in the fully adjusted model (black: OR 0.55, 95% CI 0.31-0.95; Hispanic: OR 0.48, 95% CI 0.28-0.84).

Among those individuals who used a diskus inhaler (n=219), 37% had good adherence as measured by dose counts, and those with low health literacy were more likely to have low adherence by this measure (38.8% vs. 19.5%, $p=0.004$). In logistic regression analysis of baseline data, those with low health literacy had lower odds of good adherence (OR 0.46, 95% CI 0.22-0.98, $p=0.04$) adjusting for age, sex, race and ethnicity, and years of asthma.

Inhaler Technique

Overall, inhaler technique was poor: 38% and 53% of patients correctly performed all elements of the MDI and DPI scales, respectively (Table 2). On the MDI assessment, only 43% correctly exhaled to residual volume and only 53% allowed the medication to dwell within their lungs for more than 5 seconds. Similarly, on the DPI assessment, only 47% exhaled to residual volume and 58% held the medication in their lungs for more than 5 seconds (Table 4).

For both devices, individuals with low health literacy were less likely to correctly perform these individual steps (Table 4). They also had significantly worse inhaler technique overall (MDI technique: 28% vs. 43%, $p=0.002$; DPI technique: 36% vs. 66%, $p<0.0001$; Table 2). Moreover, those with low health literacy remained less likely to have proper MDI or DPI technique in analyses that adjusted for age and sex, race and ethnicity, number of years with asthma and current use of an MDI or DPI, and functional impairment (MDI: OR 0.57, 95% CI 0.38-0.85; DPI: OR 0.42, 95% CI 0.25 to 0.71) (Table 5). These results were similar to those of the sensitivity analyses in which we defined good technique as 7 MDI steps or 5 DPI steps completed correctly.

Asthma Monitoring

Overall, only 23% of patients reported having an asthma action plan and 41% had a peak flow meter; 61% of patients reported having a regular asthma doctor (Table 2). Those with low health literacy were less likely to identify a regular asthma doctor (51% vs. 67%, $p=0.001$) in unadjusted analyses, but health literacy was not significantly associated with the other asthma monitoring measures. In adjusted analysis, low health literacy was not significantly associated with having an asthma doctor (OR 1.30, 95% CI 0.80-2.30).

Avoidance of Asthma Triggers

There was considerable variation in the extent to which patients reported using specific asthma trigger avoidance strategies, ranging from 11% of patients who keep their windows closed during spring and summer months to 91% who do not allow smoking in the home (Table 2). At baseline, use of anti-allergy bed covers was less common among individuals with low health literacy than those with adequate health literacy (24% vs. 44%, $p<0.0001$). Two strategies, however, were more common among low health literacy patients: having others perform the home cleaning (51% vs. 34%, $p=0.0005$) and avoiding animals with fur (53% vs. 36%, $p=0.0005$). There were no significant differences in use of other trigger avoidance strategies. Low health literacy remained significantly associated with use of allergy covers (OR 0.44, 95% CI 0.29-0.66, $p<0.0001$) in the adjusted analyses, as it did with avoidance of fur-bearing animals (OR 1.78, 95% CI 1.21-2.63, $p=0.004$) and having another person clean dust and mold in the home (OR 2.49, 95% CI 1.46-4.24). The latter association also maintained its statistical significance after additional adjustment for general health and impairments in activities of daily living (OR 2.2, 95% CI 1.3-3.8; $p=0.005$).

DISCUSSION

Sound self-management behavior is the cornerstone of effective asthma control.¹ In this study of older asthmatics, we found that patients with low or marginal health literacy had lower adherence to many self-management behaviors than those with adequate health literacy. Individuals with low health literacy were less adherent to asthma controller medications, both on subjective and objective measurement, and demonstrated worse technique for self-administration of inhaled steroids. These findings suggest that low adherence and poor inhaler technique may be an important mechanistic link in the causal pathway between low health literacy and adverse asthma outcomes like emergency department visits and hospital admissions.^{6,28,29}

Our findings add important data to the small body of research of health literacy and asthma self-management among elderly and non-elderly adult asthmatics.⁸⁻¹⁰ Findings from prior research in this field are generally consistent with our study, but to date they have been limited by small sample sizes, narrow scope of evaluation of self-management behaviors, and lack of attention to older populations. In a study of 73 adults with an average age of 43, Paasche-Orlow and colleagues found that asthmatics with low health literacy had lower odds of good inhaler technique (adjusted OR 0.3, $P=0.03$) and poorer knowledge of their medication regimens (adjusted OR 0.1, $P<0.01$).¹⁰ Williams and colleagues also found that low health literacy, as measured with the Rapid Estimate of Adult Literacy in Medicine, was associated with poor inhaler technique and poor asthma knowledge in a sample of adults with a mean age under 47 years.⁸ In contrast to inhaler technique, only one study examined health literacy and medication adherence and found no significant association between the two after adjustment for age, sex and race ($P=0.07$) in a sample of outpatients with a mean age of 48 years.⁹ The relatively smaller sample size of their study may partly explain the lack of a significant association ($n=248$). Alternatively, older adults with low health literacy may be more prone to problems of adherence than the non-elderly. Direct comparisons

between younger and older asthmatics would enable a better assessment of the relative vulnerability of elderly asthmatics.

Our study tested associations and cannot conclude that a causal relationship exists between low health literacy and poor self-management behaviors in older asthmatics. Nonetheless, the theoretical basis for health literacy's role in health behaviors³⁰ and evidence from empirical research provide compelling support for causality. Health literacy is posited to affect individuals' access to and understanding of health information³⁰ and studies have shown that low health literacy adults have poorer understanding of asthma and other chronic illnesses and their management^{9,31-33} and are more likely to hold misperceptions about asthma and asthma medications.³⁴ Such misperceptions are, in turn, associated with low adherence to asthma controller medications.³⁵ Illness-related beliefs pertaining to the chronicity of asthma can lead patients to use controller medications in response to symptoms rather than on a regular basis in a preventive fashion,³⁵ which reflects an understanding of the chronic nature of the disease and the controlling or preventive mechanism of action of inhaled corticosteroids, long acting beta agonists, or leukotriene inhibitors. Low literacy patients may also have problems organizing a routine that facilitates adherence or may be more likely to misunderstand the regimen.^{8,34} Finally, health literacy may influence the development of inhaler skills through acquisition of knowledge about proper inhaler use, for example, that the medication should dwell within the lungs for several seconds before exhalation. Inhaler technique has been shown to affect asthma control in both intervention and observational studies.^{36,37}

Low health literacy is associated with poorer asthma control, quality of life, and greater use of urgent care services for asthma among elderly³⁸ and non-elderly asthmatics.⁹ Given the poor outcomes of asthma among older adults and the central role of asthma controller medications for disease management, trials of low-literacy education and self-management supports to promote better adherence to asthma inhalers is warranted.

In contrast to adherence and inhaler technique, we found no consistent patterns in health literacy and trigger avoidance. Patients with low health literacy were less likely to use allergy covers on their beds, but also maintained other trigger-related behaviors at the same rate as those with adequate health literacy, including cleaning sheets in hot water and limiting their exposure to cigarette smoke and animal fur. It is not clear why patients with low health literacy were more likely to have other persons clean up dust and mold in the home. It could reflect actual preventive behavior or greater reliance on others for household chores because low literacy patients in this study were more likely to be in poor health, although the association remained significant after adjusting for general health and functional status.

Our study has important implications for clinical practice, both for individual clinicians and those designing asthma education programs. Clinicians must take the time to ascertain asthma medication adherence and assess inhaler technique with their older patients, ensuring that patients exhale to residual volume and hold their breath for 5 seconds or more. They should also routinely use educational strategies that are effective with low-literacy patients, like using teach-back and limiting the volume and complexity of information.^{39,40} The need

for routine use of such strategies is especially great in care settings that serve older adults, where the prevalence of cognitive impairment may be higher than in the general population. Health literacy and cognitive impairment are closely associated.⁴¹ Thus, clinicians who suspect cognitive impairment should communicate with their patients as they would with patients in whom they suspect low health literacy, and vice versa.

Our study has a number of strengths and some limitations. Importantly, we examined self-management behaviors in the context of an older population of asthmatics. This is a unique and important perspective because older asthmatics are twice as likely as younger asthmatics to require hospitalization for their disease, and are more likely to die from it as well^{3,4,42-44} and yet little research has been conducted to understand the underlying basis for the disparity in outcomes.⁴⁵ We also report data on a diverse sample of older adults, nearly equally represented by non-Hispanic blacks, non-Hispanic whites and Hispanics, and the study was conducted in multiple clinical venues in two large American cities, New York, NY and Chicago, IL. This diversity of patients and practice settings support the generalizability of our findings to older adults in other urban communities. However, our results may not be generalizable to patients outside of urban areas or of other races and ethnicities among whom health beliefs and behaviors may differ. Also, we used self-reports of adherence to asthma controller medications which may be subject to social desirability and other biases, although we have shown a strong correlation between MARS scores and objective measures of adherence in prior research.¹⁵

In summary, older asthmatics with low health literacy have lower adherence to asthma controller medications and poorer asthma inhaler technique than patients with higher levels of health literacy. Improving asthma outcomes for older patients will require multifactorial approaches like supporting adherence, improving inhaler skills, facilitating trigger avoidance, and maintaining a strong clinician-patient relationship with excellent communication. The success of any intervention may be greatly enhanced through careful attention to health literacy principles for older adults.

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Table 1

Demographic Characteristics of Study Patients, by Health Literacy Level at Baseline

	Health Literacy			P
	Total (n=433), %	Low, Marginal (n=155), %	Adequate (n=278), %	
Age, years				
60-64	45.0	34.2	51.1	0.001
65-74	38.6	43.2	36.0	
75	16.4	22.6	13.0	
Male Sex	16.2	16.1	16.2	0.99
Race/Ethnicity				
				<0.000
Non-Hispanic Black	30.5	31.6	29.9	1
Non-Hispanic White	21.9	3.2	32.4	
Hispanic	38.8	59.4	27.3	
Other	8.8	5.8	10.4	
Income				
				<0.000
< \$1,350 / month	54.1	80.1	39.7	1
Education				
				<0.000
<12 years	32.6	67.5	13.3	1
High school	17.4	16.2	18.0	
Some college	20.6	11.7	25.5	
College graduate	29.4	4.6	43.2	
General health				
				<0.000
Excellent or very good	23.4	9.7	31.1	1
Good	31.9	21.9	37.6	
Fair or poor	44.7	68.4	31.4	
Asthma Controller Medication Use				
Any controller medication use*	79.2	76.8	80.6	0.35
Inhaled corticosteroid use	73.0	70.3	74.5	0.35
	31.4	32.3		
Years with asthma, mean (sd)	(20.8)	(20.0)	31.0 (21.2)	0.54

* Includes patients on at least one of the following classes of asthma medications: inhaled corticosteroids, leukotriene inhibitors, long-acting beta adrenergic receptor agonists, and other miscellaneous controller medications such as theophylline, cromolyn sodium, or prednisone.

Table 2

Asthma Self-Management Behaviors, Association with Health Literacy Level at Baseline

	Total (n=433), %	Health Literacy		P
		Low, Marginal (n=155), %	Adequate (n=278), %	
Self-Report Medication				
Adherence (MARS)*	38.4	22.1	47.0	<0.0001
Correct Asthma Inhaler Technique				
Metered dose inhaler	37.9	28.1	43.3	0.002
Dry powder inhaler†	53.0	35.8	66.1	<0.0001
Asthma Monitoring				
Have an asthma action plan	22.8	19.0	24.9	0.16
Have a peak flow meter	40.9	38.1	42.5	0.37
Have one asthma doctor	61.1	50.7	66.9	0.001
Trigger Avoidance				
Use allergy covers	36.5	23.7	43.6	<0.0001
Clean bed sheets in hot water	59.3	63.8	56.9	0.17
Other person cleans mold, dust	40.0	51.0	33.8	0.0005
Keep windows closed	10.9	11.6	10.4	0.70
Never allow smoking in home	91.0	92.2	90.3	0.50
Avoid animals with fur	41.8	52.9	35.6	0.0005
Doesn't live with pets	72.5	76.1	70.5	0.21

MARS denotes Medication Adherence Reporting Scale.

* Analysis limited to individuals prescribed an asthma controller medication (n=328).

† Analysis limited to individuals prescribed a dry powder inhaler device (n=219).

Table 3

Adjusted Associations of Asthma Controller Medication Adherence with Low or Marginal Health Literacy (n=328)*

Covariates	Adjusted OR (95% CI)	P
Low, marginal health literacy	0.48 (0.31-0.73)	0.0007
Age		
60-64	Ref.	
65-74	1.06 (0.70-1.61)	0.79
75	0.88 (0.51-1.53)	0.65
Male sex	1.27 (0.74-2.17)	0.38
Race / Ethnicity		
Non-Hispanic white	Ref.	
Non-Hispanic black	0.55 (0.31-0.95)	0.03
Non-Hispanic other race	0.64 (0.31-1.34)	0.24
Hispanic	0.48 (0.28-0.84)	0.01
Number of years with asthma	1.00 (0.99-1.01)	0.68

Generalized estimating equation analyses of longitudinal data.

* Adherence as measured with the Medication Adherence Reporting Scale.

Table 4

Asthma Inhaler Technique: Percent Correct on Individual Steps and Association with Health Literacy

	Percent Performing Step Correctly			P
	All Subject s, %	Low, Marginal Health Literacy, %	Adequate Health Literacy, %	
Metered Dose Inhaler				
1. Shake inhaler and remove protective cap	59.6	56.5	61.4	0.32
2. Hold inhaler upright	97.0	94.2	98.6	0.01
3. Exhale to residual volume	43.2	31.8	49.5	0.0004
4. Place mouthpiece between lips and teeth	87.7	86.4	88.5	0.53
5. Inhale slowly, simultaneously activate canister	81.2	72.1	86.3	0.0003
6. Continue slow and deep inhalation	63.6	59.7	65.7	0.22
7. Remove inhaler from mouth when inhalation complete	89.1	85.7	91.0	0.09
8. Hold breath for 5-10 seconds	53.0	40.5	59.9	0.0001
Dry Powder Inhaler				
1. Prepare the inhaler	83.3	79.4	86.2	0.18
2. Keep inhaler horizontal	71.8	59.8	80.8	0.0005
3. Exhale to residual volume	46.9	34.0	56.6	0.0008
4. Place mouthpiece between lips and teeth	84.4	85.4	83.7	0.73
5. Inhale forcefully and deeply	79.7	75.3	83.0	0.16
6. Remove inhaler from mouth when inhalation complete	87.1	89.7	85.2	0.31
7. Hold breath for 5-10 seconds	58.2	43.8	69.0	0.0001

Table 5

Adjusted Associations of Asthma Inhaler Technique with Low or Marginal Health Literacy

Covariates	MDI Technique		DPI Technique	
	Adjusted OR (95% CI)	P	Adjusted OR (95% CI)	P
Low, marginal health literacy	0.57 (0.38-0.85)	0.006	0.42 (0.25-0.71)	0.001
Age				
60-64	Ref.		Ref.	
65-74	0.75 (0.52-1.09)	0.13	0.78 (0.46-1.34)	0.37
75	0.64 (0.38-1.09)	0.10	0.77 (0.39-1.52)	0.45
Male sex	0.93 (0.58-1.49)	0.75	1.37 (0.62-3.03)	0.43
Race / Ethnicity				
Non-Hispanic white	Ref.		Ref.	
Non-Hispanic black	0.51 (0.31-0.83)	0.007	0.48 (0.22-1.07)	0.07
Non-Hispanic other race	0.90 (0.45-1.80)	0.76	0.67 (0.23-1.92)	0.45
Hispanic	0.69 (0.42-1.13)	0.14	0.56 (0.26-1.24)	0.29
Number of years with asthma	0.99 (0.99-1.00)	0.17	0.99 (0.98-1.01)	0.32
ADL deficiencies				
0	Ref.		Ref.	
1	1.09 (0.69-1.74)	0.70	0.76 (0.41-1.40)	0.38
2	1.23 (0.72-2.10)	0.45	0.75 (0.35-1.59)	0.45

Generalized estimating equation analyses of longitudinal data.

MPI denotes metered dose inhaler; DPI, dry powder inhaler; ADL, activity of daily living.