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Patient characteristics associated with improvements in asthma control and reduction in emergency department visits for older adults with asthma

Alex D. Federman, MD, MPH^a, Erin Thanik, MD, MPH^b, Rachel O'Connor, PhD^c, Arushi Arora, MPH^a, Michael S. Wolf, PhD, MPH^c, and Juan P. Wisnivesky, MD, DrPh^a

^aDivision of General Internal Medicine, Icahn School of Medicine at Mount Sinai, New York, NY, USA; ^bDepartment of Environmental Medicine and Public Health, Icahn School of Medicine at Mount Sinai, New York, NY, USA; ^cDivision of General Internal Medicine, Feinberg School of Medicine, Northwestern University, Chicago, IL, USA

ABSTRACT

Objective: To identify patient characteristics associated with improvements in asthma control among older adults with asthma.

Methods: Secondary analysis of data from a randomized controlled trial of an asthma self-management support intervention for adults ages 60 and older with moderate-severe persistent asthma ($n = 391$). We tested the association of baseline patient characteristics with reduced emergency department (ED) visits and improvement in asthma control equal to or exceeding the minimal clinically important difference (MCID) in asthma control test (ACT) scores (3.0) 12 months.

Results: At baseline, the mean age was 68 years, 15.0% were male, 30.3% were black, and 56.5% were Hispanic. Patients with a history of ED visits in the 12 months preceding study enrollment were significantly more likely to experience an ED visit during the study period (adjusted odds ratio [AOR] 6.92, 95% confidence interval [CI] 2.18–21.9, $p < .0001$). Similarly, those with poorer asthma control (baseline ACT scores < 13) had greater odds of achieving improved asthma control (AOR 13.7, 95% CI 5.32–35.1, $p < .0001$). No other variables had statistically significant associations with the outcomes.

Conclusions: Low scores on the asthma control test and prior ED visits for asthma are strong correlates of later clinically meaningful changes in asthma control among older adults. Health systems preparing for population management of patients with asthma ought to consider incorporating serial collection of data on the ACT into the monitoring and management of older asthmatics, a high-risk patient population.

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Introduction

Asthma is a common and serious disease in older adults, affecting 7% of those ages 65 and older in the United States (1–3), and poor outcomes like hospitalizations and emergency department (ED) visits for asthma are common among them, often worse than those seen in younger adults (4,5). The disease's severity increases in a nearly linear fashion with age (4), and older asthmatics experience hospitalizations rates and asthma-related hospital length of stay that are approximately twice those of adults ages 18 to 34 years (6). Health systems are increasingly using population management practices to reduce costly hospital admissions and emergency department (ED) visits among high risk populations like older adults with asthma. However, identifying appropriate patients for resource intensive population management programs is often challenging.

We recently completed a randomized trial of a self-management support intervention for older adults, called Supporting Asthma Self-Management Behaviors of older Adults (SAMBA) (7,8). SAMBA is an asthma self-management support program that tailors patient coaching, by community health workers or care coaches, to the specific needs of each patient. In a randomized trial of the SAMBA program, intervention patients had significant improvements in asthma control and reductions in ED visits compared to usual care control patients (8). Yet the study also showed that patients in both arms experienced considerable heterogeneity of asthma control over 12 months. For the current study, we sought to identify characteristics of patients that predict outcomes over a 12-month period and that could be used to help select patients for clinical interventions to achieve better asthma control.

Methods

Patients and settings

Data for this study were from the SAMBA randomized controlled trial, conducted between February 1, 2014 and December 31, 2017 ($n=388$) (7,8). We enrolled patients aged ≥ 60 years with uncontrolled, moderate or severe persistent asthma recruited in three primary care practices of an academic medical center and a federally qualified health center in New York City. We excluded patients with other chronic pulmonary diseases or a smoking history >15 pack-years, who required assistance with medication administration, or did not speak English or Spanish. The study protocol was approved by the institutional review boards of the participating institutions (Registration: ClinicalTrials.gov, NCT02316223).

Recruitment, data collection, and intervention

Patients were identified by electronic health record query and screened by phone for eligibility. Informed consent was obtained in person followed by baseline interview then randomization. Patients were randomly assigned to usual care (control), the SAMBA intervention delivered at home, or SAMBA delivered in the primary care clinic. Research assistants conducted in-person and telephone interviews at baseline, 3, 6, and 12 months, in English or Spanish.

SAMBA is an asthma self-management support intervention, delivered by community health workers or lay health coaches that involves screening to identify barriers to asthma self-management and control and targeted actions to address the barriers. Details of the intervention are provided elsewhere (7) and materials and protocols are available at SAMBAforAsthma.org. Intervention duration was 12 months.

Outcomes measures

We examined ED visits for the 12 months and following study enrollment using data from the New York State Department of Health Statewide Planning and Research Cooperative System (SPARCS) (9). Events were attributed to asthma exacerbation if asthma was listed as the first diagnosis. For asthma control, we examined changes in the Asthma Control Test (ACT) (10) equal to or exceeding the minimal clinically important difference (MCID) in ACT scores (3.0 points) (11), in order to identify clinically significant changes.

Other measures

Informed by the Aday-Anderson model of health care utilization and the Common Sense Model of Self-Regulation (12,13), we posited that a number of factors would predispose patients to poor asthma control and use of acute care services. These include sociodemographic disadvantage (minority race and ethnicity, advanced age, lower education and health literacy, limited English proficiency, low income, low social support), poor physical and mental health, physical impairment, cognitive impairment, low adherence to self-management behaviors (medication adherence) and skills (inhaler technique), maladaptive health related beliefs and activation for participation in health care.

Social support was measured by marital status and three domains of the Patient-Reported Outcome Measurement Information System (PROMIS) Social Health questionnaires: emotional support, informational support, and social isolation (14). Physical function was assessed with the PROMIS Short Form v1.0-Physical Function 4a (14), and depression with the 8-item PROMIS short form measure (14). All PROMIS measure raw scores were converted to scaled scores as described in the PROMIS scoring manuals. Cognitive function was assessed with the Montreal Cognitive Assessment (MoCA) and the designation of cognitive impairment was based on published threshold scores (15). Adherence to asthma controller medications inhaled c(ICS and/or leukotriene inhibitors) was measured by self-report using the Medication Adherence Rating Scale (MARS) (16,17). Technique with metered dose inhalers (MDI) was assessed on placebo devices using a validated checklist (18). Finally, we assessed patients for a commonly held belief about the chronicity of asthma, in which they believe they do not have asthma if they are not currently having symptoms (19). This belief is associated with asthma controller medication adherence and asthma control in cross-sectional studies (19,20).

Data analysis

We tested the association of baseline patient characteristics with ED visits at 12 months or improvement in asthma control at 3, 6, and 12 months. The primary analyses aggregated patients in the SAMBA study's intervention and control arms. In secondary analyses, we repeated the analyses stratified by intervention and control arms. The associations of baseline patient characteristics with ED visits were assessed with the chi-square test and Wilcoxon rank sum test, as indicated. Multivariate logistic regression was then used to

Table 1. Association of baseline patient characteristics with improvement in asthma control at 12 months.

Patient characteristics	All, baseline	ACT improved > 3 points			
		12 months		Unadjusted OR (95% CI) ^a	
		Yes	No	Nonimputed	Imputed
N (%)	388	113 (43.6)	146 (56.4)	–	–
Baseline ACT score (%)					
≥20	12.4	3.5	22.5	Ref.	Ref.
13–19	56.1	52.2	56.9	4.32 (1.99–9.36)*	1.85 (1.18–2.91)**
5–12	31.5	44.3	20.6	10.8 (4.85–23.99)***	2.57 (1.61–4.11)***
Age, years (%)					
60–69	69.3	69.0	72.6	Ref.	Ref.
70–79	21.1	21.2	18.5	1.26 (0.81–1.96)	0.78 (0.56–1.08)****
≥80	9.6	9.7	8.9	1.24 (0.68–2.52)	1.17 (0.77–1.78)
Male sex (%)	15.0	14.2	19.2	0.69 (0.43–1.11)****	0.83 (0.59–1.17)
Race/ethnicity (%)					
White, non-Hispanic	7.5	6.2	6.2	Ref.	Ref.
Black, non-Hispanic	30.7	32.7	26.7	0.92 (0.47–1.77)	0.88 (0.54–1.43)
Hispanic	55.9	54.9	61.0	0.79 (0.42–1.46)	1.08 (0.68–1.72)
Other	5.9	6.2	6.2	1.22 (0.48–3.07)	1.48 (0.76–2.89)
Education (%)					
Less than high school	41.5	46.0	41.1	Ref.	Ref.
High school graduate	20.9	18.6	21.9	0.93 (0.58–1.48)	0.91 (0.65–1.26)
Some college	21.7	23.9	22.6	0.86 (0.54–1.38)	1.07 (0.77–1.49)
College graduate	15.9	11.5	14.4	1.05 (0.63–1.74)	1.09 (0.76–1.56)
Limited English proficiency (%)	36.3	35.4	39.0	0.76 (0.52–1.09)****	0.92 (0.71–1.19)
Low health literacy (%)	42.0	44.3	44.5	0.92 (0.64–1.32)	0.96 (0.74–1.23)
Monthly household income <\$1350 (%)	66.8	71.7	67.1	0.88 (0.61–1.29)	0.91 (0.70–1.18)
Married or partner (%)	23.7	26.6	21.2	1.14 (0.77–1.70)	1.02 (0.77–1.35)
Social support scores, mean (sd)					
Emotional	16.7 (4.1)	16.9 (3.8)	16.8 (4.7)	1.01 (0.97–1.05)	1.02 (0.99–1.06)****
Informational	15.3 (4.7)	15.2 (4.6)	15.6 (5.0)	0.99 (0.96–1.03)	1.01 (0.98–1.04)
Isolation	7.6 (4.3)	7.6 (4.8)	7.3 (4.2)	1.02 (0.98–1.07)	1.00 (0.97–1.03)
Physical function score, mean (sd)	12.6 (4.6)	12.7 (4.9)	12.6 (4.7)	1.01 (0.97–1.05)	0.99 (0.96–1.02)
Cognitive impairment (%)	51.8	50.4	50.7	0.98 (0.69–1.39)	0.88 (0.69–1.13)
Depression (%)	8.5	40.5	9.2	0.83 (0.43–1.61)	0.78 (0.44–1.38)
Global health score, mean (sd)	29.3 (7.0)	29.0 (6.2)	29.6 (7.5)	1.00 (0.98–1.02)	0.99 (0.98–1.01)
FEV ₁ <70% predicted (%)	43.6	42.9	42.8	0.86 (0.60–1.24)	0.80 (0.61–1.04)****
Prior ED visit for asthma (%)	10.3	14.2	6.9	2.11 (1.19–3.75)*****	1.15 (0.76–1.73)
Medication adherence score, mean (sd)	3.7 (0.7)	3.7 (0.7)	3.6 (0.7)	1.05 (0.80–1.38)	0.94 (0.78–1.14)
MDI technique, median % correct steps (range)	60 (0–100)	60 (9–100)	64 (18–100)	1.00 (0.99–1.01)	1.00 (0.99–1.01)
No symptoms no asthma belief (%)	41.2	43.8	43.8	0.97 (0.67–1.38)	1.01 (0.86–1.43)

Note. Values are column percents.

^aGeneralized estimating equation, unadjusted.

* $p < .001$, ** $p < .01$, *** $p < .0001$, **** $p < 0.25$, ***** $p < .05$.

MCID, minimum clinically important difference; ACT, Asthma Control Test; FEV₁, forced expiratory volume in 1 s; ED, emergency department; MoCA, Montreal Cognitive Assessment; PROMIS, Patient Reported Outcomes Measurement Information System; MDI, metered dose inhaler.

model ED visits. For improvement in asthma control, we first calculated the unadjusted associations of baseline characteristics with improvement in asthma control equal to or exceeding the MCID using Generalized Estimating Equations (GEE) models for the repeated measures of ACT at 3, 6 and 12 months. We then modeled the outcomes using multivariate GEE analyses. The multivariate models for ED visits and asthma control included any baseline patient characteristic variable with $p < .25$.

In a second analysis of asthma control, we used imputation to retain subjects in the model since 35.7% were missing data on the ACT at 12 months. Data on ACT scores were imputed using last observation carried forward. ED visit data were assumed to be complete for all study subjects because they were not self-reported. Owing to the exploratory nature of

these subgroup analyses, we did not correct p values for multiple comparisons. All analyses used SAS version 9.4 (SAS Institute, Cary, NC).

Results

At baseline, the mean age of study subjects was 68 years, 15.0% were male, 30.7% were Black, and 55.9% were Hispanic (Table 1). The study population was notable for low levels of education (41.5% without high school education), high prevalence of limited English proficiency (36.3%), low health literacy (42.0%), and low incomes (66.8% with monthly income <\$1350). For asthma control at baseline, 56.1% had ACT score 13–19, and 31.5% had scores <12. The percentage of subjects with an ED visit for asthma in the prior 12 months was 10.3%.

Table 2. Multivariable associations of baseline characteristics with improvement in asthma control exceeding the MCID in asthma control test scores over 12 months (3, 6, 12 months).

Patient characteristics	Nonimputed		Imputed	
	OR (95% CI)	<i>p</i>	OR (95% CI)	<i>p</i>
Age				
60–69	Ref.		Ref.	
70–79	1.53 (0.89–2.65)	.13	0.78 (0.56–1.12)	.19
≥80	1.21 (0.58–2.53)	.61	1.25 (0.80–1.96)	.33
Male sex	1.07 (0.62,1.84)	.81	–	–
Limited English proficiency	0.60 (0.40–0.91)	.02	–	–
Social support, emotional	1.04 (0.99–1.09)	.16	1.04 (1.00–1.07)	.03
ACT score at baseline				
≥20	Ref.		Ref.	
13–19	4.67 (1.95–11.2)	.0005	1.83 (1.14–2.94)	.01
5–12	13.7 (5.32–35.1)	<.0001	2.63 (1.60–4.33)	.0001
FEV ₁ < 70% predicted	0.73 (0.48–1.12)	.15	0.79 (0.60–1.03)	.08
Emergency department visit in preceding 12 months	1.69 (0.79–3.63)	.18	–	

Note. Models adjusted for subject assignment to intervention or control arm of the intervention.

ACT, asthma control test; FEV₁, forced expiratory volume in 1 s.

Correlates of achieving the MCID in asthma control test scores

Overall, the rate of achieving an improvement in asthma control that exceeded the MCID was 40.0% at 3 months, 33.5% at 6 months, and 43.6% at 12 months. Across the range of sociodemographic, health, cognitive and physical function measures, only baseline ACT score and prior ED visit for asthma were significantly associated with improvement in asthma control (for baseline ACT score <13 in the analysis of the nonimputed data set, unadjusted odds ratio [OR] 10.8, 95% confidence interval [CI], 4.9–24.0; for ED visits at baseline, OR 2.11, 95% CI 1.19–3.75) (Table 1). However, ED visits were not significantly associated with improvement in asthma control in the analysis of imputed data.

In multivariable analyses (Table 2) controlling for treatment assignment (intervention or control), patients with lower baseline ACT scores were more likely to have improvement in asthma control over 12 months. Patients with baseline ACT scores <13 had adjusted OR 13.7, 95% CI 5.32–35.1 in analysis of the nonimputed data set (imputed data set, adjusted OR 2.6, 95% CI 1.60–4.33). Other variables have significant associations with improved asthma control in the analyses of nonimputed or imputed data, but not both, including limited English proficiency (less likely to achieve asthma control) and greater emotional social support. Limited English proficiency did not meet the univariate threshold for inclusion in the multivariate analysis of imputed data.

Correlates of emergency department visits

ED visits during the 12 months of observation were more likely to occur for subjects with no high school education, an ED visit for asthma in the 12 months

prior to study enrollment, and those who believed that asthma was only present when they had symptoms (Tables 3 and 4). In multivariate analysis adjusting for treatment assignment, subjects with a prior ED visit were more likely to have an ED visit for asthma during the observation period (adjusted OR 6.92, OR 2.18–21.9). Subjects with higher levels of education were less likely to have an ED visit. No other variable was associated with ED visits during the period of observation at the level of $p < .05$.

Analyses stratified by participation in the self-management support program

Results for the stratified analyses were similar to those of the main analyses. Among patients who received the self-management support intervention, only baseline asthma control was significantly associated with improvement in asthma control, in the analysis of nonimputed data (baseline ACT score, 0–12, AOR 11.7, 95% CI 4.16–32.7; score 13–19, AOR 4.48, 95% CI 1.68–11.9) and imputed data (baseline ACT score, 0–12, AOR 2.96, 95% CI 1.47–5.95; score 13–19, AOR 1.86, 95% CI 1.00–3.44). For the ED visit outcomes, only a history of an ED visit in the preceding 12 months was associated with subsequent ED visit for asthma (AOR 9.17, 95% CI 2.28–36.9).

Results were mostly similar for patients who did not receive asthma self-management support. Only baseline ACT score was significantly associated with improvement in asthma control ([nonimputed data: baseline ACT score 0–12, AOR 6.95, 95% CI 1.37–35.4]; [imputed data: baseline ACT score 0–12, AOR 3.25, 95% CI 1.52–9.96; baseline ACT score 13–19, AOR 2.76, 95% CI 1.27–6.02]). There were no statistically significant associations of baseline patient characteristics in this group with ED visits at 12 months.

Table 3. Association of baseline patient characteristics with emergency department visits for asthma at 12 months.

Patient characteristics	≥1 ED visit	No ED visit	p
Baseline ACT score (%)			
5–12	43.8%	28.3%	.38
13–19	50.0%	58.8%	
≥20	6.3%	12.9%	
Age, years (%)			
60–69	68.8%	71.0%	.71
70–79	18.8%	22.0%	
≥80	12.5%	7.1%	
Male (%)	18.8%	15.8%	.75
Race/ethnicity (%)			
White, non-Hispanic	0	9.5%	.38
Black, non-Hispanic	31.3%	29.5%	
Hispanic	56.3%	56.0%	
Other	5.0%	12.5%	
Education (%)			
Less than high school	43.8%	38.6%	.24
High school graduate	37.5%	20.3%	
Some college	12.5%	21.2%	
College graduate	6.3%	19.9%	
Limited English proficiency (%)	37.5%	35.7%	.88
Low health literacy (%)	62.5%	42.7%	.12
Monthly household income <\$1350 (%)	75.0%	68.1%	.56
Married or partner (%)	37.5%	20.3%	.10
PROMIS social support, mean (sd)			
Emotional	16.6(4.2)	17.8 (3.3)	.67
Informational	15.3 (4.8)	15.7 (4.5)	.72
Isolation	7.7 (4.3)	6.6 (4.2)	.05
PROMIS Physical function, mean (sd)	12.6 (4.7)	12.6 (4.2)	.58
MoCA score <26 (%)	43.8%	50.6%	.59
PROMIS depression (%)	6.7%	8.9%	.77
PROMIS global health, mean (sd)	29.2 (7.0)	29.5 (6.4)	.31
FEV ₁ <70% predicted (%)	56.3%	39.6%	.19
ED visit for asthma at baseline (%)	43.8%	8.3%	<.0001
Medication adherence score, mean (sd)	3.7 (0.7)	3.8 (0.6)	.37
MDI technique, median % correct steps (range)	58.9 (23.8)	58.5 (23.5)	.27
No symptoms no asthma belief (%)	13.3%	41.4%	.03

Table 4. Multivariable associations of baseline characteristics with ED visits for asthma at 12 months.

Subject characteristics	Odds ratio (95% CI)	p
Age		.54
60–69	Ref.	
70–79	0.53 (0.16–1.78)	
≥80	1.12 (0.30–4.13)	
Education		.04
Less than high school	Ref.	
High school graduate	0.55 (0.18–1.64)	
Some college	0.15 (0.03–0.76)	
College graduate	0.13 (0.02–1.07)	
Married or partner	2.50 (0.92–6.80)	.07
Social support		
Emotional	1.06 (0.92–1.23)	.40
Isolation	0.96 (0.84–1.09)	.50
Emergency department visit in preceding 12 months	6.92 (2.18–21.9)	.001
Medication adherence score	1.85 (0.85–4.02)	.12
No symptoms no asthma belief	0.37 (0.13–1.05)	.06

Note. Model adjusted for subject assignment to intervention or control arm of the intervention.

Discussion

In this exploratory analysis of data from a randomized controlled trial of a self-management intervention for older adults with asthma, we found that low baseline ACT scores were strongly and consistently associated with clinically significant improvement in asthma control, while markers of sociodemographic disadvantage and poor physical and mental health were not. We also

found that a history of ED visits in the 12 months prior to the study period were significantly associated with likelihood of an ED visit for asthma in the subsequent 12 months. These findings were consistent whether patients received asthma self-management support or not, although prior ED visits for asthma were not associated with subsequent ED visits among patients who did not receive self-management support.

The findings of this study demonstrate variability in asthma control that many patients experience and that has been observed elsewhere (11,21–23). Johnson et al. reported that adults with asthma ($n = 429$; mean age 51 years) and who were recruited by random digit dialing in community samples experienced frequent transitions between controlled and uncontrolled asthma over 12 months as measured by self-reported asthma symptoms (21). Male subjects and those with more co-morbidities were more likely to experience worsening of asthma, but medication adherence and FEV_1 , among other variables, were not significantly associated with asthma stability. In contrast, Schatz reported that baseline asthma control predicted better asthma control at a later date based on ACT scores ($n = 1267$; mean age 45 years) in unadjusted analyses (22). Factors associated with uncontrolled asthma approximately 6 months later included indicators of worse baseline control (recent hospitalization or oral steroid use), black race and lower income. In neither the Johnson et al. nor the Schatz et al. studies was association of baseline ACT score with later control assessed in their models. Using Markov modeling of data from a randomized trial of asthma controller medications, Bateman reported that baseline asthma control predicted better control at follow up time-points (23).

The study presented here differed in important ways, both in terms of methods and results, from these and other studies of longitudinal control of asthma in adults. First, we began with a sample of patients with poorly controlled asthma at baseline. Patients with very low ACT scores have greater capacity for improvement than those with moderate scores, which is consistent with the contrasting observations of this and other studies. Patients with fair to good control of their asthma, in contrast, may have faced a ceiling effect, having relatively less room for improvement.

Second, we specifically examined clinically significant changes in asthma control as determined by the minimal clinically important difference in the ACT, rather than examining transitions across discrete thresholds (e.g. $ACT < 20$). Findings from analyses that employ the latter approach may not have the same clinical significance as a 3-point change in ACT (the MCID). The baseline ACT score may be a more sensitive indicator of risk for clinically important change in asthma control than other measures like FEV_1 or urgent healthcare utilization.

Given the high costs and morbidity associated with asthma, health systems, especially those in high

asthma prevalence areas, ought to consider adopting population management strategies to ensure that patients are reliably engaged and supported in asthma self-management practices. Health systems in states that have embarked on Medicaid's Delivery System Reform Incentive Payment (DSRIP) program may have already done so as asthma is one of the chronic diseases on which health systems participating in DSRIP may focus (24). Measures like the ACT or Asthma Control Questionnaire (ACQ), as well as ED visits for asthma occurring in the preceding year, may serve as useful markers for asthma control or poor asthma outcomes, and clinicians should be encouraged to use them.

Limitations

This study is limited by modest retention rates, which resulted in lower sample sizes at 12 months of follow-up. We addressed this limitation using imputation and found that the results of the imputed and nonimputed models were similar. The study only included individuals with poor asthma control at baseline and those recruited from clinical settings. Thus, interpretation of study findings cannot be reliably extrapolated to population-based samples of adults with asthma or those with a broader range of ACT scores at baseline. Moreover, the data analyzed in this study are from a randomized trial of an asthma self-management support intervention, which improved asthma control in the parent study. We did, however, control for treatment assignment in the analyses presented here and conducted analyses stratified by treatment assignment. This study was conducted in a single city in primarily low-income communities and thus caution should be exercised in extrapolating the results to other communities and patient populations. Finally, any ED visits occurring outside of New York state would not be captured in our data set.

Conclusions

Level of asthma control, as determined by the ACT, and prior ED visits are strong and consistent predictors of later clinically meaningful improvement in asthma control or ED visits, respectively, for patients participating in an asthma self-management program as well as those without that support. The findings of this study reinforce the observation that people with poorly controlled asthma may be most likely to improve over 12 months. Health systems prepared or preparing for population management of patients with

asthma ought to consider incorporating serial collection of data on the ACT into the monitoring and management of their at risk asthma patient populations.

Declaration of interest

The authors have no financial or personal conflicts of interest to disclose.

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