ORIGINAL INVESTIGATION

Asthma in Older Patients

Factors Associated With Hospitalization

Gregory B. Diette, MD, MHS; Jerry A. Krishnan, MD; Francesca Dominici, PhD; Ed Haponik, MD; Elizabeth Ann Skinner, MSW; Donald Steinwachs, PhD; Albert W. Wu, MD, MPH

Background: Although older adults (≥65 years) with asthma have higher rates of hospitalization and death from asthma than younger adults, the reasons for this are not known.

Objectives: To determine whether patterns of care were less favorable for older than younger adults with asthma and to assess whether patient characteristics such as symptom severity and comorbid illnesses explain the higher rate of hospitalization.

Methods: Prospective cohort study of 6590 adults with asthma in 15 managed care organizations in the United States. Participants completed a survey of demographics, symptoms, health status, comorbid illnesses, treatment, access to care, self-care knowledge, physician specialty, and health care use.

Results: Among 6590 adults with asthma, 554 (8%) were 65 years or older and 1942 (29%) were aged 18 to 34 years. Older patients were more likely than younger patients to be men, white, non-Hispanic, and less educated. At baseline, older patients reported a greater frequency of asthma-related symptoms, such as daily cough (36% vs 22%, $P<.001$) and wheezing (27% vs 22%, $P<.002$). They were also more likely to report comorbid conditions, such as sinusitis (50% vs 38%), heartburn (35% vs 23%), chronic bronchitis (43% vs 16%), emphysema (19% vs 1%), congestive heart failure (8% vs 1%), and history of smoking (54% vs 34%) (all $P<.001$). Care appeared to be better for the older patients compared with the younger, including more frequent use of inhaled corticosteroids, greater self-management knowledge, and fewer reported barriers to care. In the follow-up year, older patients were approximately twice as likely to be hospitalized (14%) than were younger patients (7%) ($P<.001$). In multivariate analysis, however, older age was not predictive of future hospitalization (odds ratio, 1.05; 95% confidence interval, 0.68-1.61), after adjustment for sex, ethnicity, education, baseline asthma symptoms, health status, comorbid illnesses, and tobacco use. Factors independently associated with hospitalization included being female, nonwhite, less educated, and less physically healthy, and more frequent asthma symptoms.

Conclusions: Although the older adults with asthma had greater respiratory symptoms and more comorbidity than their younger counterparts, chronologic age was not an independent risk for hospitalization. Appropriate care for older adults with asthma should address asthma symptoms and other chronic conditions.

Arch Intern Med. 2002;162:1123-1132

From the Department of Medicine, School of Medicine (Drs Diette, Krishnan, Haponik, Steinwachs, and Wu), and the Departments of Biostatistics (Dr Dominici), Epidemiology (Drs Diette and Wu), and Health Policy and Management (Ms Skinner and Drs Steinwachs and Wu), School of Hygiene and Public Health, The Johns Hopkins University, Baltimore, Md.

ASTHMA IS A major public health problem in the United States, affecting patients across the age spectrum, from infants to older adults. Although much research and public attention has focused on children and young adults, there has been little research on older persons (≥65 years) with asthma.[1,2] Although the prevalence of asthma may be similar in older and younger adults, ranging from 4% to 9%,[3] morbidity and mortality are greater in older patients. The death rate attributable to asthma is 14 times higher for persons 65 and older compared with those 18 to 35, with 89.8 deaths vs 6.3 deaths per million, respectively.[2] Among 5400 deaths from asthma reported in the United States between 1993 and 1995 for all ages, 2900 (54%) were among people 65 and older.[2] Similarly, older adults are hospitalized at more than twice the rate of younger adults, with a rate of 25.6 hospitalizations per 10 000 compared with 10.0 per 10 000 for persons aged 15 to 34.[2]

Older adults shoulder a disproportionate burden of health care use and mortality, but little is known about how asthma differs in this subset of the population.[4] For some medical illnesses, studies[5,6] have shown that older patients receive less vigorous management. In some severely ill patients, chronologic age was not related to

PATIENTS AND METHODS

STUDY DESIGN

This study used patient-reported data from baseline and 1-year follow-up in a cohort study to examine patterns of asthma treatment and the association of baseline patient factors with future hospitalization.

STUDY POPULATION

The Managed Health Care Association Outcomes Management System Asthma Project was undertaken by 11 large employers and their managed care partners to test the feasibility and usefulness of patient-reported information to improve the quality of patient care.[10] Fifteen managed care organizations participated in a prospective longitudinal study that included an initial patient baseline survey and 2 annual patient follow-up surveys.

Study participants were selected from the pool of enrollees in each managed care organization, using claims data or other central information sources. Three inclusion criteria were applied: (1) age 18 or older on September 1, 1993; (2) enrollment in the managed care organization at the time of sampling; and (3) 2 or more medical care encounters (outpatient visits or hospitalizations) with a diagnosis of asthma (*International Classification of Diseases, Ninth Revision, Clinical Modification* code 493 and its subclassifications) between September 1, 1991, and August 31, 1993. The sampling pool was divided into 2 strata: (1) those who had at least 1 hospitalization or emergency department visit during the past 24 months and (2) those who had all of their asthma contacts in outpatient settings. From each of these groups, at least 300 patients were selected from each health plan. If fewer than 300 patients had hospitalizations or emergency department visits, the outpatient group was expanded so that the total baseline sample numbered at least 600 patients. Individuals were excluded from the baseline assessment if they stated that they did not have asthma or had disenrolled or expected to disenroll from the managed care organization before January 1, 1994.

DATA COLLECTION

During August 1993, 10 539 patients were sampled, of whom 8640 were eligible for the study. Reasons for ineligibility included not having asthma (844 patients), disenrollment (839 patients), and "other" (216 patients). From September 1993 through December 1993, data were collected from patients by mail survey, with telephone follow-up of nonresponders to increase the response rate. The completion rate for the baseline survey was 76% (6590 patients). Of the 6590 patients who completed the baseline survey, 4876 (74%) completed the 1-year follow-up survey. Response rates were higher in older patients: 18 to 34 years (66%), 35 to 44 (73%), 45 to 54 (76%), 55 to 64 (80%), and 65 and older (86%) ($P<.001$).

VARIABLES

The independent variables collected on the baseline survey included the following:

Patient Demographics

Demographic variables included sex, age, ethnicity (white, black, or "other"), education (eighth grade or less, some high school, high school graduate, some college, college graduate, or any postgraduate work), and employment status (working full time, working part time, unemployed, keeping house, attending school, disabled, or retired).

Symptoms

Asthma symptom questions were based on the symptom types and frequencies used by the National Asthma Education and Prevention Program[9] and international[11] asthma guidelines and included cough, sputum production, chest tightness, wheezy or whistling sound in the chest, and shortness of breath (never, once a week or less, 2-3 times a week, 4-5 times a week, or daily over the past 4 weeks). Patients were asked how many times in the past 4 weeks asthma had awakened them from sleep (never, once, 2-4 times, 5-7 times, or ≥8 times), how frequent asthma attacks were (not at all, less than once a week, once or twice a week, or ≥3 times a week), and how their breathing was in between attacks (no problems, some symptoms on some days, some symptoms on most days, or symptoms most of the time). Patients also reported the degree to which in the past 4 weeks asthma caused them to rearrange or cancel normal activities (not at all, a little bit, some, or quite a bit) and caused emotional problems (not at all, a little bit, some, or quite a bit). To avoid problems associated with collinearity in multivariate analysis used to account for symptom frequency, an asthma symptom index was created based on the answers to 7 symptom questions (chest tightness, wheezing, shortness of breath, cough, sputum production, nocturnal symptoms, and persistence of symptoms between attacks).[12] The responses to each item were summed and divided by the number of nonmissing values. The range for the asthma symptom index is 1 to 5, with a higher score indicating more symptoms. A previous study[10] found that the asthma symptom index score was associated with the frequency of inhaled β-agonist use.

Health Status

General health status was assessed with questions from a 36-item short-form (SF-36 Health Survey).[13] The 36-item short-form is a general health status measure that produces 8 subscales, which can be combined into 2 summary scores. The physical health component summary score includes physical functioning, physical role functioning, bodily pain, and general health. The mental health component summary score includes energy (vitality), social functioning, emotional role functioning, and mental health. Scores are standardized so that they range from 0 to 100, with a population mean of 50. Higher scores indicate better health.

Comorbidity

Comorbid conditions were reported by patients as present or absent, including sinusitis, heartburn, congestive heart failure, chronic bronchitis, emphysema, and allergies

or hay fever. These conditions were selected as potential causes of worsening asthma or illnesses with symptoms that overlap those of asthma.

Treatment

Indicators of treatments were based on recommendations of the National Asthma Education and Prevention Program guidelines.[9] Indicators of drug treatment included whether medications of certain classes were used by patients for asthma. Medication classes included β-agonist inhalers, anticholinergic and cromolyn sodium inhalers, inhaled corticosteroids (ICSs), oral theophylline, oral corticosteroids, and oral β-agonists. Inhaled corticosteroid use was assessed for days of use per week (none, <1, 1-2, 3-4, 5-6, or 7 days) and daily dose (1-4, 5-8, 9-12, or >12 puffs per day). Underuse of ICS was considered to be use on 4 or fewer days per week or 4 or fewer puffs per day of use.[10] β-Agonist inhaler use was quantified as puffs per day on days of use (1-4, 5-8, 9-12, or >12 puffs per day). Overuse of β-agonists was considered to be use of more than 8 puffs per day on days of use.[10] We assessed whether a patient possessed a peak flow meter, had been shown how to use it, had received instructions regarding what to do if the peak flow fell below a specified level, and frequency of use. Finally, we asked about prophylactic measures that patients take for worsening of asthma.

Access to Care

Access to care for patients with an acute asthma problem was assessed by yes or no answers to questions about trouble reaching a physician or nurse by telephone, getting an appointment to see a physician, or getting medication for asthma. We also assessed whether patients had drug coverage as a covered health insurance benefit.

Patient Knowledge

Knowledge was assessed by answers to questions about whether patients believed they had been given enough information by the physician or nurse to report knowing "everything you need to know about what to do when you have a severe flare-up of your asthma," "how to adjust medicine when your asthma gets worse," and "what things can make your asthma worse and how to avoid them." Patients also rated their own knowledge about what to do in a severe asthma attack, on a 5-point scale (from poor to excellent).

Physician Specialty

The patient was asked to name the physician primarily responsible for managing his or her asthma and to give the physician's specialty. The specialty was categorized as a generalist (internist or family practitioner), allergist, or pulmonologist.

Health Care Use

Baseline health care use for asthma was assessed by the number of office visits in the past 6 months, telephone calls to the physician in the past 6 months, emergency department visits in the past year, and hospital admissions in the past year.

For the multivariate model, the dependent variable was the patient's yes or no report of hospitalization for asthma during the year following the baseline survey.

STATISTICAL ANALYSIS

We tested the hypothesis that greater asthma symptom severity and comorbid illness explained the higher rate of hospitalization of older adults (≥65 years) compared with younger adults (18-34 years).

MANAGEMENT OF MISSING DATA FOR INDEPENDENT VARIABLES

The results in this article are presented with substitutions made for missing values. Approximately one quarter of the respondents had at least 1 missing response. For variables with missing responses from fewer than 10% of respondents, the missing value was replaced with the median for continuous or ordinal variables and mode for nominal variables. For variables with at least 10% of responses missing, we developed a data augmentation algorithm for imputation of missing data based on multiple conditional imputation.[14,15] Each missing value for a subject was imputed by using data from the responding subjects in the sample having a similar covariate profile. In this strategy, all independent variables were imputed using the same method. The imputation was performed by accounting for the correlation structure of the independent variables, and 5 multiple imputations were performed to estimate the uncertainty due to the imputation. Sensitivity of the analyses to missing values was evaluated by comparing the difference between odds ratios (ORs) using the data set with missing values and ORs from imputed data sets. The approach used may produce SEs that are slightly higher or lower than if missing data had been "ignored." Factors from multivariate models of borderline statistical significance (or nonsignificance) should be interpreted with caution.

Variables were examined by descriptive frequencies and cross-tabulations. Age was grouped as 18 to 34, 35 to 44, 45 to 54, 55 to 64, and 65 years and older. Bivariate analyses were performed using *t* tests for continuous variables and χ^2 tests for categorical items. Differences were considered statistically significant at $P<.05$. In the bivariate analyses of variables that used imputation, if all the *P* values for multiple imputation were significant, we reported the highest *P* value leading to the most conservative approach. If all the *P* values for the multiple imputation were not significant, then the *P* value was not reported. The *P* values are not sensitive to the multiple imputation, and there were no cases in which some *P* values were significant and others were not. A multivariate model to predict future hospitalization was developed in 2 stages. The relationship between patient factors at baseline and subsequent hospitalization was first examined in bivariate analyses by χ^2 test (nominal variables), χ^2 test for trend (ordinal variables), and Kruskal-Wallis test (continuous variables). Items that were statistically significant in bivariate analysis or that were considered clinically important

Continued on next page

were examined in multivariate models, using logistic regression analysis. Multivariate models were developed in each sampling stratum (inpatient and outpatient); because there were no important differences between the two, a model combining all patients is reported. Results are reported with ORs and 95% confidence intervals. Pooled ORs and confidence intervals were estimated by combining the results of the 5 data sets resulting from imputation. Individual ORs and their statistical variances were obtained by fitting the model to each imputed data set. We then estimated a pooled OR by averaging the individual ORs, and estimated the pooled variance by taking the average of the individual variances plus the variances of the individual ORs. From the pooled variance, we calculated the pooled confidence interval. Statistical computations were performed with SAS version 6.12.[16]

outcomes, after accounting for severity of illness factors.[7] These findings suggest not only that older patients may receive less care or may be sicker but also that advanced chronologic age may not always be the cause of poorer outcomes. In the case of asthma, investigators[8,9] have suggested that blunted awareness of respiratory discomfort may lead to delays in seeking treatment and to undertreatment of underlying airways inflammation. As with other medical conditions, asthma care may be less vigorous in older patients, or its management could be complicated by greater frequency and severity of comorbid illnesses and poorer disease-specific or general health status.

To examine why older adults with asthma are frequently hospitalized, this investigation aimed to determine (1) whether quality of care was less favorable for older adults and (2) whether patient characteristics such as symptom severity and comorbid illness, which are predictive of hospitalization, explain the different age-related rates of hospitalization in patients enrolled in managed care.

RESULTS

Among 6590 patients who completed the baseline survey, 8% were 65 years or older, 27% were 18 to 34, and 65% were 35 to 64. A higher proportion of older patients (65-94 years) were men, white, and non-Hispanic. The older patients also were significantly less educated. (**Table 1**).

BIVARIATE ANALYSES

Respiratory Symptoms and Functional Effects of Asthma

As shown in Table 1, the older patients tended to report significantly greater symptom frequency than the younger patients, with the greatest differences in daily shortness of breath, cough, and sputum production. The asthma symptom index score was higher for the older compared with the younger patients (2.9 vs 2.7, $P<.001$). The frequency of nocturnal awakenings was slightly less with older age, and asthma "attacks," although common, were less frequent among older than younger patients (67% vs 74%, $P<.001$). The older patients were more likely to have canceled scheduled activities because of asthma and to report emotional problems because of their asthma (54% vs 45%, $P<.001$).

Comorbid Conditions and Overall Health

Conditions that worsen asthma symptoms or that cause symptoms similar to those of asthma (Table 1) were significantly more prevalent in the older patients, including sinusitis, heartburn, and congestive heart failure. Older patients were more likely to have ever smoked (54% vs 34%, $P<.001$) and reported concomitant lung conditions more frequently, including chronic bronchitis and emphysema. On the other hand, allergies and hay fever were inversely related to age, with 86% of the younger group reporting them vs 68% of the older patients ($P<.001$). The physical health component summary score on the 36-item short-form was substantially lower (worse) for the older patients compared with the younger patients (mean score, 49.6 vs 80.8, $P<.001$), whereas the mental health component summary scores were similar.

Patients Who Never Smoked

Because differences in disease characteristics seen between older and younger adults could reflect misclassification of disease or effects of tobacco exposure in older patients, we performed analyses confined to patients who never smoked. The overall patterns of respiratory symptoms and comorbidity by age were similar in never smokers (**Table 2**). However, compared with all older patients, the older patients who never smoked were more likely to be female (75% vs 65%) and less likely to report a comorbid diagnosis of chronic bronchitis (40% vs 43%) or emphysema (8% vs 19%). Daily cough and sputum production were reported more frequently in the older patients who never smoked compared with the entire group of older patients, but there was less frequent wheezing and shortness of breath, although these differences were slight. Asthma attacks were less frequent and symptoms between attacks were also more favorable in the older patients who never smoked.

Barriers to Care

Compared with the younger patients, older patients in this study were less likely to report barriers to care when there was a problem with their asthma (**Table 3**). Older patients were less likely to report difficulty reaching a physician by telephone, difficulty getting an appointment to see the physician, or a problem in getting medications. The older patients who had not seen an asthma specialist were also less likely to indicate that they wanted to see one (15% vs 24%, $P<.002$).

Medications

Older patients were more likely to use medications commonly prescribed for respiratory conditions, including

Table 1. Characteristics of Patients With Asthma by Age Group*

Characteristic	Age, y					*P* Value
	18-34 (n = 1775)	35-44 (n = 1744)	45-54 (n = 1523)	55-64 (n = 994)	≥65 (n = 554)	
Female sex	69.2	74.4	70.4	66.7	64.8	.004
Ethnicity						
White	83.0	79.9	80.9	82.8	88.3	
Black	11.8	15.8	15.2	13.0	8.7	.02
Other	5.2	4.3	3.9	4.2	3.1	
Hispanic	7.0	4.8	4.5	3.5	1.6	<.001
<High school education	3.7	6.0	11.2	21.3	34.1	<.001
Full-time employment	69.1	73.0	73.0	48.1	8.5	<.001
Asthma characteristics						
Pet, food, or dust makes asthma worse	84.5	81.5	78.5	70.9	62.4	<.001
Symptoms daily in past 4 wk						
Cough	22.0	26.5	27.9	33.0	35.9	<.001
Sputum production	17.6	20.9	23.4	28.2	31.0	<.001
Chest tightness	21.4	21.8	21.2	22.5	26.4	.06
Wheezing	22.5	22.4	24.5	26.3	27.1	.002
Shortness of breath	24.3	26.4	30.0	36.0	42.8	<.001
Awakened ≥5 times in the past 4 wk	21.3	22.4	20.4	18.0	18.8	.02
≥1 Asthma attack in past 4 wk	73.6	71.6	69.9	67.6	67.2	<.001
Symptoms most of the time between attacks	6.7	8.9	11.0	11.2	13.9	<.001
Mean asthma symptom index (1 [low] to 5 [high])	2.70	2.76	2.77	2.84	2.92	<.001
Canceled activities because of asthma	31.9	35.3	37.8	37.8	43.1	<.001
Emotional problems from asthma	45.3	45.1	48.6	48.6	54.2	<.001
Asthma control excellent in past year	12.4	12.8	14.2	13.9	9.4	.74
Tobacco exposure						
Ever smoked	33.9	42.7	51.8	56.8	53.6	<.001
Passive smoke	66.6	58.8	60.3	54.0	41.5	<.001
Comorbid conditions						
Sinusitis†	38.5	46.2	52.4	46.5	49.6	<.001
Heartburn	23.3	30.1	36.5	35.2	35.4	<.001
Congestive heart failure	0.56	1.2	2.7	5.2	7.8	<.001
Chronic bronchitis†	16.1	22.8	29.1	36.6	42.8	<.001
Emphysema	0.79	1.5	4.9	11.5	18.8	<.001
Allergy or hay fever	85.7	80.2	76.7	71.9	68.2	<.001
Mean SF-36 physical component score	80.8	75.6	68.6	61.8	49.6	<.001
Mean SF-36 mental component score	70.2	69.1	69.0	71.9	69.0	.004

*Data are given as percentages unless otherwise indicated. Some percentages do not sum to 100 because of rounding. SF-36 is the trademark for the Medical Outcomes Study 36-Item Short-Form Health Survey.

†Proportion is mean of proportions from 5 imputed data sets. *P* value was statistically significant in all 5 data sets and always equal to .001.

theophylline (51% vs 32%), inhaled ipratropium bromide (22% vs 6%), oral β-agonists (37% vs 23%), and oral corticosteroids (37% vs 15%) (all $P<.001$). Although rates of possession of ICSs and inhaled β-agonists were similar across the age groups, older patients used ICSs more regularly. Overuse of inhaled β-agonists was significantly greater among the older patients.

Information and Knowledge and Self-management

The older patients, more frequently than the younger, reported having received all they needed to know about how to adjust medications when the asthma is worse and were slightly more likely to know the triggers that worsen asthma and how to avoid them (Table 3). Older patients were more likely to report having been told all they needed to know about what to do during a severe flare-up (61% vs 49%), but were less likely to rate this knowledge as excellent (12% vs 23%) (both $P<.001$). The older patients were also more likely to use a peak flow meter daily (28% vs 12%, $P<.001$). Older patients were less likely to use asthma medications for worsening of symptoms, but were more likely to take antibiotics, call their physician, or go to an emergency department.

Risk of Hospitalization

The older patients were approximately twice as likely to be hospitalized during the follow-up year after baseline as the younger patients (14% vs 7%, $P<.001$, **Table 4**). Other baseline patient factors that were significantly associated with future hospitalization included female sex, nonwhite ethnicity, less education, and active and passive tobacco exposure. Patients with greater baseline asthma symptom severity, worse overall health status, and the presence of certain comorbid conditions (heartburn, sinusitis, congestive heart failure, chronic bronchitis, and emphysema) were also more likely to be hospitalized. Similar associations with hospitalization were seen in the subset of adults who never smoked, although a few of these associations were not statistically significant.

Table 2. Characteristics of Patients With Asthma Who Never Smoked, by Age Group*

Characteristic	Age, y					*P* Value
	18-34 (n = 1173)	35-44 (n = 1000)	45-54 (n = 734)	55-64 (n = 429)	≥65 (n = 257)	
Female sex	66.1	73.9	74.4	73.0	75.1	<.001
Ethnicity						
White	81.0	80.6	78.9	77.4	87.6	
Black	13.6	14.5	16.6	15.8	9.3	.64
Other	5.4	4.9	4.5	6.8	3.1	
Hispanic	6.8	5.8	4.5	4.9	1.6	<.001
<High school education	2.0	4.2	8.2	14.7	35.8	<.001
Full-time employment	69.2	74.4	74.0	51.0	9.0	<.001
Asthma characteristics						
Pet, food, or dust makes asthma worse	87.4	84.9	81.5	72.3	64.6	<.001
Symptoms daily in past 4 wk						
Cough	18.4	23.1	23.8	28.7	38.9	<.001
Sputum production	15.4	18.2	19.1	24.7	32.7	<.001
Chest tightness	19.5	21.8	18.3	21.0	25.7	.20
Wheezing	20.4	20.1	20.7	23.8	26.1	.03
Shortness of breath	22.2	24.5	27.2	28.2	40.5	<.001
Awakened ≥5 times in the past 4 wk	20.4	22.3	19.8	18.4	20.2	.42
≥1 Asthma attack in past 4 wk	73.0	70.9	69.8	62.7	64.6	<.001
Symptoms most of the time between attacks	5.9	8.2	10.0	8.2	12.4	<.001
Mean asthma symptom index (1 [low] to 5 [high])	2.62	2.70	2.66	2.72	2.91	.002
Canceled activities because of asthma	31.9	35.3	36.8	33.6	39.3	.03
Emotional problems from asthma	42.6	43.6	45.9	45.7	52.5	.005
Asthma control excellent in past year	12.5	12.9	14.3	13.0	9.3	.67
Comorbid conditions						
Sinusitis†	36.4	45.9	51.6	45.3	51.0	<.001
Heartburn	20.0	26.8	33.9	35.9	37.0	<.001
Congestive heart failure	0.51	1.1	1.8	3.5	8.6	<.001
Chronic bronchitis†	13.6	18.9	25.5	28.8	39.5	<.001
Emphysema	0.17	0.40	1.6	2.6	8.2	<.001
Allergy or hay fever	87.6	81.3	80.1	73.0	68.9	<.001
Mean SF-36 physical component score	81.8	77.5	70.9	66.0	51.3	.0001
Mean SF-36 mental component score	71.9	70.7	71.5	73.2	70.3	.20

*Data are given as percentages unless otherwise indicated. SF-36 is the trademark for the Medical Outcomes Study 36-Item Short-Form Health Survey.
†Proportion is mean of proportions from 5 imputed data sets. *P* value was statistically significant in all 5 data sets and always equal to .001.

MULTIVARIATE ANALYSIS

In multivariate analysis, older age was no longer significantly associated with future hospitalization, after controlling for asthma symptom severity, health status, comorbidity, tobacco exposure, and demographics (**Table 5**). Being female, nonwhite, less educated, less physically healthy, and more severe asthma symptoms remained significant predictors of hospitalization.

COMMENT

Consistent with previous findings from national data,[2] the older patients in this study were at substantially higher risk of hospitalization. However, chronologic age was not an independent risk factor for being hospitalized. Instead, older patients in this study had a higher prevalence of other risk factors that predict hospitalization, including more respiratory symptoms, worse general health, and limited education. Although the older adults were more likely to have smoked and to report having concomitant chronic obstructive pulmonary disease, these factors alone did not account for the different rate of hospitalization. Favorable findings for the older patients included their reporting fewer barriers to care when needed and being more likely to receive many elements of asthma care that are recommended by guidelines. Nevertheless, there was still substantial room for improvement in care, as it appeared insufficient to control symptoms and avert hospitalization.

Older patients reported a different pattern of symptoms compared with the younger patients, suggesting potential differences in expression of asthma or a blending of symptoms from multiple medical conditions, potentially obscuring their primary airways disease. The symptom pattern suggests a more stable, less episodic illness. For example, although several symptoms were more likely to be reported daily, the relative difference was greatest for cough, sputum production, and shortness of breath and less for wheezing and chest tightness. In addition, older adults were less likely to report having symptoms of nocturnal awakening and asthma attacks, but more likely to report symptoms "most of the time." Clinicians need to be aware of these clinical presentations in older patients and to maintain a high index of suspicion of asthma. Other investigators have found different patterns of symptoms according to age. For example, a study[17] of older (≥65 years) and younger (<40 years) asthmatics showed that

Table 3. Process of Care in Patients With Asthma, by Age Group*

Characteristic	Age, y					*P* Value
	18-34 (n = 1775)	35-44 (n = 1744)	45-54 (n = 1523)	55-64 (n = 994)	≥65 (n = 554)	
Health care provider						
Generalist	62.8	61.3	63.3	59.2	62.3	.07
Pulmonologist	18.0	19.8	20.4	28.0	25.4	
Allergist	17.8	17.1	14.7	10.8	10.2	
Other specialist	1.4	1.8	1.6	2.0	2.0	
Seen specialist in past year	37.2	36.9	40.2	35.8	37.0	.002
Not seen specialist, but would have liked to	24.0	20.1	15.9	14.4	14.8	
Medication						
β-Agonist inhaler	95.3	96.1	94.2	92.7	92.6	<.001
Overuse of β-agonist inhaler	12.6	12.8	15.8	15.1	17.2	<.001
Ipratropium bromide	5.6	7.6	10.4	12.9	22.2	<.001
Cromolyn sodium inhaler	12.4	12.4	10.0	8.6	8.3	<.001
Inhaled corticosteroid (ICS)	62.0	69.0	69.7	72.9	71.1	<.001
Underuse of ICS	68.1	64.6	58.1	54.5	48.0	<.001
Theophylline	31.6	36.6	42.7	48.2	50.7	<.001
Oral β-agonist	23.0	26.7	27.9	33.5	36.6	<.001
Oral corticosteroid†	15.4	19.2	23.2	27.6	36.9	<.001
Self-monitoring						
Has peak flow meter (PFM)	25.7	26.0	26.3	23.6	22.2	.08
Among those with PFM						
Told what to do with low peak flow	78.3	78.4	79.0	77.0	71.5	.24
Daily PFM use	12.1	17.4	19.2	29.4	28.5	<.001
Mean No. of health care encounters						
Talked to physician on phone (1 yr)	3.0	3.3	2.8	2.7	2.4	<.001
Office visits in past 6 mo	2.3	2.4	2.5	2.5	2.4	.02
Emergency department visits in past y	0.78	0.65	0.56	0.52	0.56	<.001
Avoidance and prophylaxis						
Told how to avoid triggers	77.4	79.8	81.2	77.9	77.1	.66
Prophylaxis measure						
Use cromolyn sodium inhaler†	10.7	10.2	9.0	7.4	6.8	<.001
Use bronchodilator†	62.6	61.7	56.5	50.7	47.3	<.001
Use ICS†	26.3	27.4	27.1	27.7	25.5	‡
Treatment for worsening						
ICS	34.3	36.8	37.0	32.5	26.9	.007
β-agonist inhaler	82.1	81.2	77.2	70.8	69.3	<.001
Antibiotics†	19.6	21.0	25.5	25.9	26.4	<.001
Oral corticosteroid†	21.4	23.6	23.8	21.4	16.2	.09
Call physician	47.4	56.1	59.4	63.9	61.7	<.001
Go to emergency department	30.2	28.0	28.5	31.5	37.5	.02
Ever allergy evaluation	73.1	73.1	69.7	67.7	61.0	.001
Knowledge						
Knows all needed for						
Flare-up	49.0	53.2	54.7	57.4	61.2	<.001
Adjusting medications	43.3	48.6	50.7	50.9	52.4	<.001
How to avoid triggers	51.2	54.0	54.0	53.7	58.3	.01
How to handle attack (excellent knowledge)	23.4	22.8	21.0	19.5	12.1	<.001
Access problem						
Has drug coverage	92.3	91.9	93.6	90.9	76.2	<.001
During flare-up						
Unable to reach physician by phone	10.0	8.1	7.0	5.2	3.8	<.001
Unable to get appointment	13.5	11.3	8.7	6.5	5.8	<.001
Trouble getting medications	16.1	11.2	7.1	5.8	5.0	<.001

*Data are given as percentages unless otherwise indicated. Some percentages do not sum to 100 because of rounding.
†Proportion is mean of proportions from 5 imputed data sets. *P* value was statistically significant in all 5 data sets, and largest *P* value is reported.
‡Proportion is mean of proportions from 5 imputed data sets. All *P* values were not statistically significant.

mild symptoms and symptom-free periods were less likely in older patients. The reasons for these varying observations are unclear. In our investigation, the high prevalence of reports that symptoms are triggered by certain environmental exposures (pets, food, and dust) and concurrent reports of hay fever suggest that this difference is not simply misclassification of illness. Rather, it seems that this reflects a different constellation of asthma symptoms in older adults, or that symptoms are modified by concomitant illnesses.

The high prevalence of comorbid medical conditions in our study is consistent with other reports and is

Table 4. Association of Baseline Characteristics With Future Hospitalization for Patients With Asthma*

Baseline Characteristic	All Patients With Asthma (n = 4876)	*P* Value	Never Smokers Only (n = 2464)	*P* Value
Age, y				
18-34	7.4		5.7	
35-44	7.4		7.0	
45-54	8.8	.001	7.7	<.001
55-64	9.9		8.5	
≥65	14.4		15.4	
Sex				
Female	10.2	.001	8.7	<.001
Male	5.4		4.6	
Ethnicity				
Nonwhite	13.8	.001	12.4	<.001
White	7.8		6.6	
Hispanic				
No	8.7	.35	7.4	.17
Yes	10.7		10.8	
Education				
≤Eighth grade	17.9		17.5	
Some high school	18.3		20.7	
High school graduate	10.1	.001	8.5	<.001
Some college	8.5		8.7	
College graduate	6.3		4.5	
Any postgraduate work	3.5		3.5	
Comorbid conditions				
Sinusitis				
No	7.8	.02†	6.8	‡
Yes	9.9		8.5	
Heartburn				
No	7.8	.001	7.0	.10
Yes	11.1		9.0	
Congestive heart failure				
No	8.5	.001	7.6	.53
Yes	20.0		10.3	
Chronic bronchitis				
No	7.1	.001†	6.4	.001†
Yes	13.7		12.1	
Emphysema				
No	8.4	.001	7.4	.02
Yes	16.8		18.2	
Hay fever				
No	9.8	.23	8.0	.69
Yes	8.6		7.5	
Ever smoked				
No	7.6	.002	NA	NA
Yes	10.2			
Passive smoke				
No	7.8	.05	6.1	.009
Yes	9.5		8.9	
Asthma control in past y				
Poor or fair	17.2	.001	15.4	<.001
Good, very good, or excellent	6.5		5.6	
Attacks in past 4 wk				
No	4.0	.001	2.7	<.001
Yes	10.8		9.6	
Functional status of nonhospitalized vs hospitalized patients				
Mean SF-36 physical component score				
Hospitalized				
No	72.8	.001	75.7	<.001
Yes	55.2		58.4	
Mean SF-36 mental component score				
Hospitalized				
No	70.8	.001	72.2	<.001
Yes	63.9		66.4	
Asthma symptom index of nonhospitalized vs hospitalized patients				
Hospitalized				
No	2.7	.05	2.6	.44
Yes	3.3		3.3	

*Data are given as percentages hospitalized during the follow-up year after baseline unless otherwise indicated. SF-36 is the trademark for the Medical Outcomes Study 36-Item Short-Form Health Survey. NA indicates not applicable.

†Proportion is mean of proportions from 5 imputed data sets. *P* value was statistically significant in all 5 data sets, and the largest *P* value is reported.

‡All *P* values were not statistically significant. Proportion is mean of proportions from 5 imputed data sets.

relevant to the presentation, recognition, and management of older patients with asthma. Reporting results of the Cardiovascular Health Study (a study of patients aged ≥65 years), Enright and colleagues[18] showed that many patients with "definite" asthma had high frequencies of hay fever (60%), chronic bronchitis (28%), and emphysema (12%). A study[19] using interview and medical chart review data from older asthmatics also revealed a high prevalence of chronic obstructive pulmonary disease and sinusitis. Coupled with the present study findings (Table 2), the high frequency of comorbid conditions underscores the importance of recognizing and treating other conditions likely to coexist in the older asthmatic. The high prevalence of reported allergy triggers (62%) is a reminder that older patients, too, may benefit from environmental measures to control their asthma. Indeed, management of comorbid conditions may affect nearly all older patients with asthma, as 91% of our study patients reported at least 1 comorbid condition. The finding that older patients who never smoked reported emphysema (8%) and chronic bronchitis (40%) is interesting, as it may suggest that physicians label older patients with respiratory symptoms as having chronic obstructive pulmonary disease when primarily they may have asthma.

Although we hypothesized that unfavorable differences in care between older and younger adults might explain increased hospitalization, we were encouraged to see that older patients reported more favorable care across a broad array of care indicators. Care appeared more appropriate in the use of some medications, including regular use of ICSs, periodic assessment of disease, avoidance and prophylaxis measures, self-knowledge, and use of specialists. Indeed, the older patients were less likely to report problems with access to providers, although they may experience difficulty paying for expensive medications, as they were less likely to have insurance coverage for medications. Although some clinicians may assume that older patients with asthma may be less receptive to using comprehensive asthma care programs, these older patients often reported more favorable approaches to the use of medications, fewer barriers to care, and more knowledge and self-management of their disease. We believe this observation is important and supports an optimistic view that clinicians' efforts expended in education of older patients with asthma will prove worthwhile.

On the other hand, although care appeared to be better for older than younger patients, there were still marked opportunities for improvement. For example, 37% of the older adults reported recent use of oral corticosteroids, raising concerns about long-term consequences of this medication, including loss of bone density, adrenal suppression, and other serious adverse effects. It is interesting that theophylline was used by half of these older patients and oral β-agonists by 37%, despite the untoward effects in older patients. Limited or infrequent use of ICSs was reported by nearly half of the older patients, and more than 40% of the older patients reported not knowing everything they needed to know to manage flare-ups, adjust medications, or avoid asthma triggers. Most patients did not have a peak flow meter, and of those who did have one, 29% did not know what to do in the case of a low reading.

Table 5. Multivariate Analysis of Predictors of Future Hospitalization for Asthma

Characteristic	Odds Ratio (95% Confidence Interval)
Age, y	
18-34	1
35-44	0.80 (0.58-1.11)
45-54	0.80 (0.57-1.13)
55-64	0.78 (0.53-1.15)
≥65	1.05 (0.68-1.61)
Sex	
Female	1
Male	0.56 (0.42-0.75)
Ethnicity	
White	1
Black	1.79 (1.34-2.39)
Other	2.02 (1.22-3.34)
Education	
College graduate	1
High school graduate	1.36 (1.02-1.82)
<High school graduate	2.18 (1.48-3.22)
Comorbid conditions	
Sinusitis	0.90 (0.71-1.14)
Heartburn	1.10 (0.87-1.39)
Congestive heart failure	1.10 (0.64-1.89)
Chronic bronchitis	1.12 (0.84-1.46)
Emphysema	0.90 (0.58-1.39)
Functional status*	
SF-36 physical component score	0.99 (0.98-0.99)
SF-36 mental component score	1.00 (0.99-1.00)
Tobacco exposure	
Ever smoked	1.20 (0.96-1.52)
Passive smoke	1.05 (0.82-1.33)
Asthma symptom index (1 [low] to 5 [high])	1.53 (1.35-1.74)

*SF-36 is the trademark for the Medical Outcomes Study 36-Item Short-Form Health Survey.

There are limitations to interpretation of our study results. Misclassification of disease status is possible in this study, with some patients reporting a physician's diagnosis of asthma that should have been chronic bronchitis or emphysema. We believe that the analyses limited to never smokers, however, show that such misclassification is unlikely to be the major explanation for our findings. In addition, we have used a definition of asthma that is consistent with that used by the Centers for Disease Control and Prevention[2] in establishing asthma prevalence rates in the United States and for documenting a greater morbidity of asthma in older adults. Factors that affect the quality of survey data include less education, impaired cognitive status, and worse physical and mental health, all of which tend to be more frequent in older patients.[20] Multiple studies[21-23] have shown, however, that health status information can be reliably obtained by survey from older adults, including those with comorbid health conditions. When the reliability of health status reports has been examined in different age groups, some measures are affected slightly by older age.[24] Older adults have been shown to have a "rosy" response bias, with a tendency to report in a socially desirable direction.[25] Because memory problems tend to increase with age, there may have been a bias toward underreporting of symp-

toms and comorbid illness in the older patients. Also, although the findings show that there is room to improve care, we do not have information about whether care patterns reflect provider behavior or patient preferences for care. The study was performed only in patients enrolled in managed care, so the findings may not be generalizable to patients who receive care under other arrangements. Because patient demographics, disease severity, and the process of care might be expected to differ considerably in other circumstances, further study focused on asthma in older patients in other care settings is essential.

Despite these limitations, the present observations have important implications, not only for individual patients and their health care providers but also for health care planners. With the progressive aging of the US population, health care costs attributable to hospitalization for asthma will increase, even if hospitalization rates for older adults remain stable. A recent study[26] of Medicare recipients shows that the number of hospitalizations for asthma among older persons is rising. Identifying reasons for hospitalization and adverse consequences of asthma in the older adult and developing interventions to address these problems should be a priority for researchers and health care planners. This study demonstrates that older adults with asthma are sicker than their younger counterparts and that the care they receive may often be inadequate. Older adults with asthma have more comorbid illnesses than younger patients, and health care plans and programs that manage asthma need to consider more than a single disease in the older adults. Coordination of care among multiple care providers is often necessary and introduces more challenges in management, but may prove crucial for the optimal care of the older asthmatic.

Accepted for publication September 26, 2001.

This work was supported by the Managed Health Care Association, Washington, DC.

Corresponding author and reprints: Gregory B. Diette, MD, MHS, Department of Medicine, School of Medicine, Johns Hopkins University, Room 301, 1830 E Monument St, Baltimore, MD 21205 (e-mail: gdiette@jhmi.edu).

REFERENCES

1. Chan ED, Welsh CH. Geriatric respiratory medicine. *Chest*. 1998;114:1704-1733.
2. Centers for Disease Control and Prevention. Asthma mortality and hospitalization among children and young adults: United States, 1980-1993. *MMWR Morb Mortal Wkly Rep*. 1996;45:350-353.
3. Enright PL, Kronmal RA, Higgins MW, Schenker MB, Haponik EF. Prevalence and correlates of respiratory symptoms and disease in the elderly. *Chest*. 1994;106:827-834.
4. Tuuponen T, Keistinen T, Sirkka-Liisa K. Hospital admissions for asthma in Finland during 1972-86 of adults aged 65 years and over. *Age Ageing*. 1993;22:97-102.
5. Gugliano RP, Camargo CA, Lloyd-Jones DM, et al. Elderly patients receive less aggressive medical and invasive management of unstable angina: potential impact of practice guidelines. *Arch Intern Med*. 1998;158:1113-1120.
6. Borum ML, Lynn J, Zhong Z, for the Study to Understand Prognoses and Preferences for Outcomes and Risks of Treatments. Blood transfusion administration in seriously ill patients: an evaluation of SUPPORT data. *J Am Geriatr Soc*. 2000;48(suppl 5):S39-S43.
7. Ely EW, Evans GW, Haponik EF. Mechanical ventilation in a cohort of elderly patients admitted to an intensive care unit. *Ann Intern Med*. 1999;131:96-104.
8. Connolly MF, Crowley JJ, Charan NB. Reduced subjective awareness of bronchoconstriction provoked by methacholine in elderly asthmatic and normal subjects as measured on a simple awareness scale. *Thorax*. 1992;47:410-413.
9. *Guidelines for the Diagnosis and Management of Asthma: Expert Panel Report Number 2*. Bethesda, Md: National Heart, Lung, and Blood Institute, National Institutes of Health; 1997. NIH publication 97-4051.
10. Diette GB, Wu AW, Skinner EA, et al. Treatment patterns among adult asthmatics: factors associated with overuse of inhaled β-agonists and underuse of inhaled corticosteroids. *Arch Intern Med*. 1999;159:2697-2704.
11. National Heart, Lung, and Blood Institute, National Institutes of Health. International consensus report on diagnosis and treatment of asthma. *Eur Respir J*. 1992;5:601-641.
12. Steinwachs DM, Wu AW, Skinner EA, Young Y. *Outcomes Management System Asthma Final Report: Report to the Managed Health Care Association*. Bethesda, Md: Outcomes Management System Asthma Project; 1996.
13. Ware JE, Kosinski M, Keller SD. *The SF-36 Physical and Mental Health Summary Scales: A User's Manual*. Boston, Mass: Health Institute, New England Medical Center; 1994.
14. Rubin DB. Multiple imputation after 18+ years. *J Am Stat Assoc*. 1996;434:973-989.
15. Rubin DB, Little RJA. *Multiple Imputation for Nonresponse in Surveys*. New York, NY: John Wiley & Sons Inc; 1987.
16. *SAS, Version 6.12*. Cary, NC: SAS Institute Inc; 1999.
17. Quadrelli SA, Roncoroni AJ. Is asthma in the elderly really different? *Respiration*. 1998;65:347-353.
18. Enright PL, McClelland RL, Newman AB, Gottlieb DJ, Lebowitz MD, for the Cardiovascular Health Study Research Group. Underdiagnosis and undertreatment of asthma in the elderly. *Chest*. 1999;116:603-613.
19. Bailey WC, Richards JM, Brooks CM, Soong S, Brannen AL. Features of asthma in older adults. *J Asthma*. 1992;29:21-28.
20. Stewart AL, Sherbourne CD, Brod M. Measuring health-related quality of life in older and demented populations. In: Spilker B, ed, *Quality of Life and Pharmacoeconomics in Clinical Trials*. Minnetonka, Minn: Lippincott-Raven; 1996:819-830.
21. Gloth FM, Walston J, Meyer J, Pearson J. Reliability and validity of the frail elderly functional assessment questionnaire. *Am J Phys Med Rehabil*. 1995;74:45-53.
22. Kutner NG, Ory MG, Baker DI, Schechtman KB, Hornbrook MC, Mulrow CD. Measuring the quality of life of the elderly in health promotion intervention clinical trials. *Pub Health Rep*. 1992;107:530-539.
23. Katz JN, Chang LC, Sangha O, Fossel AH, Bates DW. Can comorbidity be measured by questionnaire rather than medical record review? *Med Care*. 1996;34:73-84.
24. Sherbourne CD, Meredith LS. Quality of self-report data: a comparison of older and younger chronically ill patients. *J Gerontol*. 1992;47(suppl):S204-S211.
25. Carp FM. Maximizing data quality in community studies of older people. In: Lawton MP, Herzog AR, eds. *Special Research Methods for Gerontology*. Amityville, NY: Baywood; 1989.
26. Cydulka RK, McFadden ER, Emerman CL, Sivinski LD, Pisanelli W, Rimm AA. Patterns of hospitalization in elderly patients with asthma and chronic obstructive pulmonary disease. *Am J Respir Crit Care Med*. 1997;156:1807-1812.