Association of Asthma Control with Health Care Utilization

A Prospective Evaluation

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Population-based disease management should be enhanced by good risk assessment models and instruments. We prospectively evaluated the ability of a simple measure of short-term asthma control (scored 0 to 4) to predict asthma 12-mo health care utilization (HCU). A total of 5,172 adult asthma patients completed a brief questionnaire in fall 1997 to assess current level of asthma control. We then evaluated HCU for calendar year 1998. Ninety-three percent had health plan eligibility in 1998 and were included in this analysis. Both acute and routine asthma utilization increased with increasing numbers of asthma control problems. Rates of acute care episodes were 3.5 (95% confidence interval [CI] = 2.9, 4.3) times more likely for those with 3 to 4 control problems versus those with no control problems. Lesser, but statistically significant, increases were seen for those with two (relative risk [RR] = 1.7, 95% CI = 1.4, 2.2) or one (RR = 1.4, 95% CI = 1.1, 1.8) control problems. These patterns were similar for men and women, and diminished with increasing age. The asthma control index contributed significantly to prospective prediction models even after adjusting for administrative data such as medication use and prior HCU. These data reinforce the usefulness of measures of short-term asthma control both for the individual clinician and for those interested in population-based asthma management.

Keywords: asthma; level of control; health care utilization; severity; asthma disease management

The past decade has seen an increasing emphasis on improving the management of asthma, both in the clinician's office (1) and in populations served by groups, such as large health maintenance organizations (2), interested in population-based disease management (3). In part, this reflects both the increase in asthma prevalence (4) and the recognition that asthma is a chronic condition that, for many, requires ongoing daily controller medication to maintain good disease control (5). Despite the existence of national treatment guidelines (4), many patients with asthma continue to be undertreated and are therefore at greater risk for acute exacerbations that result in reduced quality of life, missed work or school, and expensive health care utilization (HCU) (6–8).

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To operate a disease management program or manage a panel of asthmatic patients efficiently, health plan administrators and clinicians need to be able to identify those individuals who are at greatest risk for acute exacerbations. Large administrative and clinical databases offer one solution to this problem and have been used to predict hospitalization and emergency department (ED) care for asthma (5, 9–13).

In the absence of such administrative and clinical databases, or to increase the predictive value of models derived from them, other tools are needed to identify those patients who are most in need of aggressive follow-up and management. A variety of predictive indices have been developed and tested in cross-sectional analysis (14–19), but as yet only one has been shown to predict HCU prospectively (20, 21). For the clinician, a measure of asthma control (6) may be as, or more, important than the level of severity when making decisions about therapeutic management. It is both easier to assess and more indicative of the patient's current state.

We have previously described a brief, self-administered questionnaire, five items of which can be used to assess current level of asthma control. We suggested it, or similar measures of asthma control, could be used as a possible "asthma vital sign" to be measured routinely in the clinical setting, much as we now routinely measure height, weight, blood pressure, and symptoms (22). Such a tool could also be used to assess the impact of population-based disease management efforts. In cross-sectional analysis, this index showed marked discriminatory properties in terms of self-reported HCU in the prior year and generic and disease-specific quality of life (22). The present study reports on a 12-mo prospective evaluation of this instrument to determine its ability to predict future asthma HCU, both acute (hospital, ED, and other acute care) and routine outpatient care.

METHODS

A more complete description of the study population and methods can be found in the online data supplement.

Study Population

In the fall of 1997, we identified 5,172 adult members of a large managed care organization who reported doctor-diagnosed asthma and recent use of asthma medications, and surveyed them to assess current level of asthma control (22). This analysis focuses on the 4,795 (93%) who had six or more months of health plan eligibility (mean = 11.8 mo) in 1998.

Survey Instrument

The Asthma Therapy Assessment Questionnaire (ATAQ) is a brief self-administered questionnaire designed to assess level of asthma control and identify possible disease management problems. The resulting control index ranges from 0 to 4 and reflects level of control in the last 4 wk.

TABLE 1. 1997 ADMINISTRATIVE DATA USED TO PREDICT 1998 ACUTE ASTHMA HEALTH CARE UTILIZATION*

Number of inpatient admissions for asthma
Number of ED visits for asthma
Number of other acute visits for asthma
Number of routine care visits for asthma
Total number of asthma medication dispensings, excluding prednisone
Number of β-agonist dispensings
Ratio of β-agonist to inhaled corticosteroid dispensings
Number of prednisone dispensing

* All variables computed for all of 1997.

Health Care Utilization

We used the health plan's administrative and clinical databases to assess HCU for 1998 and classify encounters as acute care (inpatient admissions, ED care, and other acute care) or routine care.

Statistical Methods

Acute HCU data are presented both as rates of individual encounters and as rates of acute episodes of care. We computed the latter by identifying all acute asthma contacts and then treating adjoining contacts that occurred fewer than 3 d apart as being part of a single, ongoing acute exacerbation that has not fully resolved (23). Rates of individual encounters may be of greater interest from a health plan perspective because they translate directly into dollars. However, the distinction between encounters is sometimes arbitrary (e.g., hospitalization from the emergency department listing as two records in the database). The episode methodology avoids some of the statistical problems posed by this clustering and also may have greater appeal from an epidemiologic perspective.

We used Poisson regression analysis (24) to compare differences in rates of HCU among the individuals with varying numbers of control problems, and to adjust these comparisons for age and sex. For computation of relative risks (RR) in the tables, we treated number of control problems as a categorical variable. However, we treated number of control problems as a linear variable to test for trend. We used logistic regression analysis to compare proportions of individuals with various types of HCU, again adjusting comparisons for age and sex as appropriate.

To look at the relative utility of the asthma control index versus administrative data in predicting future HCU, we fit an additional series of Poisson regression analyses to model the rate of asthma inpatient stays, asthma ED visits, and acute asthma episodes. For each outcome, we fit three separate models. The first model included the administrative variables listed in Table 1. These variables were patterned after, although not identical to, those used by Lieu and coworkers (13) in their analysis of prediction models for hospitalization and ED visits. We retained all of these variables in the model, regardless of their significance. The second model included both the administrative variables and indicators for one, two, and three or four control problems. Both models also included sex and indicators for the age groups 40 to 54, 55 to 64, and ⩾ 65.

We used the likelihood ratio test to compare the goodness-of-fit of model 1 with model 2, thus examining the marginal contribution of the control index after adjusting for the administrative variables. We also used model 1 to develop quartiles of risk based on administrative data, and then examined the predictive power of the control index within each of these quartiles.

RESULTS

Table 2 presents the characteristics of the study sample and of the 377 individuals who were excluded from the analysis because of insufficient follow-up. Individuals in the latter group were significantly younger and less likely to have had dispensings of inhaled corticosteroids in the baseline year than were those included in the analysis. The two groups were very similar in terms of their baseline asthma control scores and (self-reported) coexisting chronic obstructive pulmonary disease (COPD). Because of the limited number of individuals with four control problems, this group was combined with the three-problem group in all subsequent analyses. Although information on race was not captured as part of the interview, according to the latest census data over 81% of the greater Portland metropolitan area's population is white, not of Hispanic origin.

Table 3 shows the rates of the various types of acute asthma HCU encounters and also of routine asthma care encounters, as a function of sex and baseline asthma control. For each of the three types of acute encounters (hospitalization, ED visit, and other acute care), and for routine encounters, rates of HCU increased steadily with increasing numbers of control problems for both men and women. With the exception of inpatient data for men ($p = 0.24$), all of the trends seen

TABLE 2. CHARACTERISTICS OF STUDY POPULATION AT BASELINE

	Study Cohort (*n* = 4,795)	Excluded Participants (*n* = 377)	p Value*
Age, yr mean ± SD (min, max)	52.3 ± 16.3 (17, 93)	43.9 ± 18.7 (17, 93)	< 0.001
Female	67.5%	64.2%	0.21
Self-reported COPD†	35.0%	32.3%	0.33
ICS use‡	37.6%	28.4%	< 0.001
ED/hospital care for asthma§	6.0%	4.5%	0.23
Management plan‖	22.7%	21.2%	0.50
ATAQ Control Index¶			
No problems	48.5%	45.6%	
One problem	23.6%	22.2%	
Two problems	15.2%	17.2%	0.45
Three problems	9.9%	11.1%	
Four problems	2.6%	3.7%	

* Two-sided p values based on either *t* test (age), continuity adjusted chi-square test (sex, COPD, use of inhaled corticosteroids), or standard Pearson chi-square test.

† Self-report of doctor-diagnosed chronic bronchitis, emphysema, or COPD.

‡ One or more dispensings of inhaled corticosteroids during 1997 (baseline year).

§ Asthma ED care or hospitalization with primary discharge diagnosis of asthma during 1997.

‖ Self-report of written treatment plan for asthma attacks.

¶ See supplemental materials on the online data supplement for a more complete definition of ATAQ Control Index.

TABLE 3. PROSPECTIVE RATES OF ASTHMA HEALTH CARE UTILIZATION, PER 1,000 YEARS OF ELIGIBILITY, AS A FUNCTION OF BASELINE LEVEL OF ASTHMA CONTROL AND SEX*

No. of Asthma Control Problems	No. of Subjects	Person-Years Follow-up	Type of Visit: Rate per 1,000 Person-Years			
			Inpatient	ED Care	Other Acute	Routine
Women						
None	1,560	1,537	6	23	88	837
One	753	740	11	26	110	1,013
Two	503	495	26	61	125	1,227
3–4	422	410	41	129	210	1,690
Men						
None	767	758	9	21	51	726
One	379	374	5	37	91	803
Two	227	225	18	44	71	991
3–4	184	179	17	117	150	1,310
Overall						
None	2,327	2,294	7	23	76	800
One	1,132	1,113	9	30	103	942
Two	730	720	24	56	108	1,153
3–4	606	590	34	126	192	1,574

* Trend chi-square significant at $p = 0.0001$ for all sex-outcome combinations except inpatient utilization in males ($p = 0.24$) based on Poisson regression analysis adjusting for age. Overall trends significant at $p = 0.0001$ for all outcomes based on Poisson regression adjusting for age and sex.

TABLE 4. PROSPECTIVE RATE OF ACUTE ASTHMA EPISODES (NUMBER OF EPISODES PER 1,000 PERSON-YEARS OF ELIGIBILITY) AS A FUNCTION OF NUMBER OF ASTHMA CONTROL PROBLEMS, AGE, AND SEX

No. of Asthma Control Problems	Age Group (*yr*)					
	Rate per 1,000 Person-Years					
	18–39	40–54	55–64	65–101	All Ages	RR for All Ages*
Women	(n = 698)	(n = 1,173)	(n = 595)	(n = 772)	(n = 3,238)	
None	104	95	91	103	98	1.00
One	119	140	87	162	132	1.34 (1.04, 1.72)
Two	139	227	187	87	166	1.72 (1.32, 2.24)
3–4	516	312	196	104	304	3.35 (2.66, 4.21)
Men	(n = 290)	(n = 455)	(n = 288)	(n = 524)	(n = 1,557)	
None	69	67	67	56	64	1.00
One	190	102	85	61	102	1.67 (1.09, 2.54)
Two	180	129	84	50	107	1.73 (1.07, 2.80)
3–4	360	311	75	202	236	4.28 (2.87, 6.40)
Overall	(n = 988)	(n = 1,628)	(n = 883)	(n = 1,296)	(n = 4,795)	
None	93	87	84	85	87	1.00
One	141	130	86	120	122	1.41 (1.14, 1.75)
Two	151	201	159	72	148	1.72 (1.37, 2.17)
3–4	484	312	152	144	283	3.54 (2.90, 4.29)

* Relative risks (RR) versus no control problem group based on Poisson regression analysis adjusting for age and sex groups (overall) or age (sex-specific). Ninety-five percent confidence intervals shown in parentheses.

with increasing numbers of control problems were also highly statistically significant ($p = 0.0001$). For example, compared with women with no control problems, women with 3 or 4 control problems were 7.1 times more likely to be hospitalized, 5.5 times more likely to be seen in the ED, 2.3 times more likely to have other acute care, and twice as likely to have routine asthma care visits. Similar figures for men were 1.8, 5.8, 3.1, and 1.8. Except for the hospitalization data, which due to their infrequent numbers are the least reliable statistics, the RR were remarkably similar for men and women, even though women tended to have substantially higher HCU rates than men for non–hospital-based care.

The higher RR for hospitalizations and ED care, relative to the two remaining outcome categories, are a reflection of the lower rates in the "no control problem" group for the hospitalization and ED outcomes. On an absolute basis, the number of excess events (i.e., attributable risk) for those with 3 to 4 versus zero control problems were fairly comparable for the ED and other acute care outcomes and were substantially greater for the routine care outcomes, some of which may reflect acute care occurring in the outpatient clinics during regular business hours, although the majority probably reflect appropriate, ongoing routine care for these patients.

Table 4 shows the rate of acute episodes of care by age, sex, and number of control problems. The overall rates are less than the sum of the individual acute care rates in Table 3 because some episodes include more than one encounter. For women younger than 65 yr of age and men under age 55, the data show a remarkably consistent pattern of increasing acute episodes of care with increasing numbers of control problems. This pattern is largely muted in the older groups and may reflect the confounding effects of COPD in these groups. (That is, the diagnostic information may be less reliable in these older cohorts.) After adjusting for age and sex, the number of control problems was highly significant ($p < 0.0001$). Overall, RR for one, two, and three to four control problems, relative to no control problems, were 1.41 (95% confidence interval [CI] = 1.14, 1.75), 1.72 (95% CI = 1.37, 2.17), and 3.54 (95% CI = 2.90, 4.29), respectively. These did not differ significantly by sex, although they did differ significantly by age.

Analysis of routine asthma care visits by age and sex (data not shown) revealed a similar pattern, in that the RR associated with increasing numbers of control problems did not differ significantly by sex but did differ by age. Overall, after adjusting for sex and age, RR for one, two, and three to four control problems, relative to no control problems, were 1.18 (95% CI = 1.09, 1.27), 1.44 (95% CI = 1.33, 1.56), and 1.96 (95% CI = 1.81, 2.12), respectively. These RR were both somewhat smaller and much more precise than those from Table 4, again reflecting the much larger rate of events in the group with no control problems.

The proportion of individuals with acute care contacts during 1998 also increased steadily with increasing numbers of control problems, from 7.7% to 19.3% overall (data not shown). As with the analysis of RR in Table 4, the odds ratios relating the use of acute care services to number of control problems did not vary by sex, but did vary by age.

Reflecting the much higher rate of routine versus acute health care visits, the proportion of individuals with routine asthma HCU was also substantially higher than the proportion with acute asthma HCU (data not shown). Overall, between 41% and 49% of study subjects had at least one routine visit for asthma during the follow-up year, depending on the number of control problems reported during the baseline assessment. These figures, or more precisely the associated odds ratios, did not differ significantly by age or sex. Given that the overall rate of routine asthma HCU visits averaged around 1,000 per 1,000 person-years, the fact that less than half of these individuals had routine care implies that those who did averaged more than two such visits per year.

The ability of the control index to predict HCU persisted even after adjustment for administrative data on prior HCU and medication use, although the strength of the association diminished. For example, based on Poisson regression analysis adjusting for age and sex, the risk for the rate of acute asthma episodes was estimated to increase by a factor of 49% for each additional control problem (95% CI = 40, 60). After further adjustment for the variables listed in Table 1, this increase was only 23% (95% CI = 15, 33). Other significant predictors for increasing risk in this model were younger age, female sex, number of ED visits, number of other acute visits, number of routine care visits, and total number of dispensings of prednisone. A similar pattern was seen for the rate of ED visits, with the risk declining from 80% per control problem (95%

TABLE 5. PROSPECTIVE RATE OF ACUTE ASTHMA EPISODES (NUMBER OF EPISODES PER 1,000 PERSON-YEARS OF ELIGIBILITY) AS A FUNCTION OF NUMBER OF ASTHMA CONTROL PROBLEMS AND RISK STRATA*

	No. of Asthma Control Problems			
	Rate per 1,000 Person-Years			
Risk Quartile	None	One	Two	3–4
0–25%	47	51	41	102
25–50%	79	87	77	83
50–75%	63	130	77	145
75–100%	216	242	308	532

* The risk quartiles were obtained from a multivariate model containing the following administrative data: age, sex, asthma health care (hospital admissions, ED, urgent care, nonurgent outpatient), β-agonist and prednisone dispensings, ratio of β-agonist to inhaled corticosteroid dispensings.

CI = 59, 102) before adjustment to 35% (95% CI = 18, 54) after adjustment. After adjustment, the number of control problems was not associated with subsequent hospitalizations for asthma.

Table 5 presents the rate of acute asthma episodes associated with various numbers of control problems for participants in each of four quartiles of risk defined based on age, sex, and the administrative data in Table 1. On an absolute basis, rates of acute care episodes generally increase with increasing risk quartile, and within each risk quartile, those with three or four control problems generally have the greatest risk. However, it is only in the top quartile of risk (defined by administrative data) that we see a clear gradient with increasing numbers of control problems.

DISCUSSION

We have shown that a brief, easy-to-administer index of current asthma control prospectively predicted both acute and routine HCU for asthma, over a 12-mo period, among 4,795 adult members of a large health maintenance organization (HMO). More than 50% of this population had at least one control problem, and 13.5% had three or four control problems. Overall, rates of acute asthma episodes were 3.5 (95% CI = 2.9, 4.3) times more likely for those with three to four control problems versus those with no control problems, whereas results for those with one or two control problems were intermediate. Findings were similar for men and women, and were limited primarily to those under age 65. The asthma control index contributed significantly to prospective prediction models even after adjusting for measures of prior HCU and medication use derived from administrative and clinical databases.

The population from which this sample was derived was originally identified on the basis of two or more antiasthma medication dispensings or ED/hospital care for asthma and therefore included a mix of individuals with and without asthma (22). The response rate to the survey was 62% (not atypical for other surveys of this population), and was significantly higher for older, as opposed to younger, individuals. Of those who did respond, 32% denied having doctor-diagnosed asthma (about half of these reported having COPD); another 8% either were not currently taking asthma medications or else did not fill out their survey completely and thus also were excluded from the current analysis. Finally, the 377 excluded for lack of follow-up data were slightly younger and significantly less likely to have had a dispensing for inhaled corticosteroids in the baseline year than those included in the analysis. The potential therefore exists that the study cohort may systematically differ from asthmatics in the parent population, thus limiting generalizability. Although the health plan membership is known to be broadly representative of the larger Portland metropolitan population, minority representation in this area is low, and this may also limit generalizability. Nonetheless, this large, well-characterized cohort still represents a very diverse population in terms of age, sex, socioeconomic status, and health status (25), and we believe that valid inferences may be drawn from it.

Several researchers have demonstrated the utility of using large administrative databases to identify patients at increased risk for asthma exacerbations and to predict HCU in adults and children. Lieu and coworkers (13) used pharmacy dispensing and HCU data on 101,110 asthmatic adults enrolled in an HMO to develop a model for predicting subsequent hospitalization and ED care for asthma. They were able to prospectively identify patients with up to a fourfold increased risk for such encounters. A subsequent study yielded similar results in 16,520 asthmatic children (12). Donahue and coworkers (5) documented the predictive value of asthma drug dispensings for assessing the risk of future hospitalization in 16,941 asthmatic members of an HMO over a period of 3 yr. Grana and coworkers (11) used HMO data on pharmacy dispensings and prior HCU for asthma to stratify 54,573 asthmatics for risk of hospitalization in the following year, and then validated the model in a further group of 75,124 HMO members. They found good correlation between predicted and actual hospitalizations for asthma.

The preceding studies are all based on predictors of severity/control that are typically defined over periods of a year or more. Short-term measures of asthma control, such as those described in this report, have been less well studied. Such measures are important for two reasons. First, individual clinicians who do not have ready access to information from administrative databases can still readily assess short-term asthma control at the point of service. Second, a short-term measure of asthma control may, much like traditional patient vital signs, be the more-relevant clinical metric for determining therapeutic decisions. For example, a well-managed, compliant patient with moderate persistent disease who is taking controller medication regularly may be at much lower risk for acute exacerbations than is a patient with mild persistent disease who is taking only β-agonist bronchodilators on an as-needed basis and who experiences frequent symptoms (6, 15, 26). Even though the latter patient has less severe asthma, the condition is likely to have a much more negative influence on his or her life than on the more severe patient who is under good control (6).

In addition to the ATAQ index, we are aware of one other published measure of asthma control (14) and two variations on that instrument (18, 27). Numerous asthma symptom scales also measure aspects of control. Many asthma "severity" scales also include measures of short-term control, which perhaps is not surprising given that national guidelines define severity in terms of level of control in the unmanaged patient (4). Cowie and coworkers, in a one-year prospective evaluation of 378 adult asthma patients, reported significant risks for future ED care associated with each of the following: activity limitation, nocturnal waking, and increased β-agonist use (28), and Balkrishnan and coworkers have shown that quality of life predicts future ED and hospital care in elderly patients with asthma (29).

The present study, with follow-up data on 4,795 members of an HMO, is the largest study thus far published on the properties of a pure asthma control index. We have also published data on the cross-sectional association of the ATAQ index with quality of life and self-reported HCU in this cohort

(22). That analysis, even more so than this one, demonstrated a clear gradient in response across all five values of the scale, thus supporting the independent contribution of each dimension of control to the index. Detailed analysis of the individual components of control suggested that activity limitation contributes the most predictive power, whereas reliever overuse contributes the least amount of information. The present analysis would seem to support the value of all four indices, in that the group with three to four control problems (at least for those under age 65) consistently exhibited the greatest rates of HCU. Because of the small sample sizes, we chose to combine the groups with three and four problems for this analysis. Separate analyses, not presented here, failed to show a consistent pattern of increase from three to four control problems, and thus we recommend that these two categories be collapsed when using the instrument.

Information on asthma control can be used in several ways to assist with asthma disease management. First, such information might be useful as part of a routine office visit for patients with asthma to alert clinicians to patients who may benefit from a change in their asthma management plan, although further work in the clinical trial setting needs to be done to document whether the index is responsive to treatment. Based on its cross-sectional association with quality of life, each additional control problem appears to correlate with what has been reported as clinically significant mean reductions in quality of life (22).

Second, health plans or other organizations interested in population-based disease management can use a measure of asthma control such as that derived from the ATAQ questionnaire to conduct surveys to better identify asthmatic patients in need of follow-up care, or to further stratify those asthmatics determined to be at elevated risk on the basis of administrative data. Patients with three to four control problems on our scale and a history of high resource use, for example, may warrant more aggressive management services. Finally, asthma control may also provide a basis for measuring the outcome of new services implemented as part of a continuous quality improvement program (30).

In summary, these findings reinforce the usefulness of short-term asthma control as a theoretical construct and practical instrument, at least in those younger than 65 yr of age. Our asthma control instrument should be useful not only to the individual clinician evaluating a patient, but also as an adjunct to administrative data for managed care organizations and other groups, such as state health divisions, who may be interested in population-based asthma management.

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