

Factors associated with acute health care use in a national adult asthma management program

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Background: The use of acute health care resources for asthma is considerable. Disease severity is an established risk factor, but ethnicity and health care factors are less well studied.

Objective: To investigate the independent associations of ethnicity and health care factors with acute resource use for asthma.

Methods: Longitudinal data from a national adult asthma management program providing universal access to care were analyzed. Outcome measures were unscheduled physician visits with urgent nebulization, emergency department (ED) visits, and hospitalizations.

Results: In multivariate analyses, markers of disease severity were found to be significantly associated with all acute resource use. After controlling for disease severity, ethnicity was associated with increased risk of all acute resource use; Indian (vs Chinese) ethnicity was associated with increased risk of unscheduled physician visits (hazard ratio [HR], 1.32; 95% confidence interval [CI], 1.03–1.70), ED visits (HR, 1.61; 95% CI, 1.12–2.32), and hospitalizations (HR, 1.49; 95% CI, 1.03–2.16). Malay ethnicity was associated with unscheduled physician visits (HR, 1.30; 95% CI, 1.01–1.68) and ED visits (HR, 1.55; 95% CI, 1.09–2.19). Default of follow-up appointments was associated with unscheduled physician visits (HR, 1.47; 95% CI, 1.08–2.00), ED visits (HR, 2.35; 95% CI, 1.59–3.45), and hospitalizations (HR, 1.74; 95% CI, 1.09–2.76). Poor inhaler technique was associated with ED visits (HR, 1.86; 95% CI, 1.05–3.30) and smoking with unscheduled physician visits (HR, 1.38; 95% CI, 1.09–1.76).

Conclusions: In addition to markers of asthma severity, ethnicity, smoking, discontinuity of care, and self-care behavior are risk factors for acute resource utilization and represent target groups and elements of asthma intervention for improving asthma outcomes.

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INTRODUCTION

Despite therapeutic advances, asthma remains an important cause of ill health in the population and consumes considerable health care service resources.¹ This occurs because many patients who have poorly controlled asthma have frequent relapse of asthma attacks requiring unscheduled visits to physicians, emergency department (ED) visits, or admissions to the hospital. Delineating the factors^{2–37} that contribute to increased use of acute health care services for asthma is key to targeted and effective intervention. Clinical and proxy markers of disease severity^{13,15,24,30,34} are consistently reported to be important predictive factors. However, the effects of

ethnicity and self-care behavior factors are much less understood.

Ethnicity^{13–26} has been reported in population studies to be associated with higher hospitalization rates for asthma. Whether such ethnic disparity in acute services use is attributable to differences in disease severity, socioeconomic status, health care access, or other factors is not well understood.

An estimated 4.5% of the population in Singapore reported a physician diagnosis of asthma in their lifetime, and 2.2% reported experiencing asthma in the current year.³⁸ It is the fifth most common reason for hospital discharges.³⁹ Previous population-based studies have documented that in multiethnic Singapore, the prevalence of current asthma in Malays (3.3%) and Indians (4.5%) is higher than that in Chinese people (0.9%). Rates of asthma hospital admissions were higher in Malays (3.3 per 1,000) and Indians (4.1 per 1,000) than in Chinese people (1.2 per 1,000).⁴⁰ Also, asthma mortality rates in Malays and Indians were 4 and 2 to 3 times higher, respectively, than in Chinese people.⁴¹

In this prospective open cohort study, we investigated the factors associated with subsequent urgent physician visits, ED visits, and hospital admissions. In particular, we examined whether ethnicity was a risk factor, independent of disease severity and other risk factors, and whether patient self-care behavior and other potentially modifiable factors were associated with acute resource use.

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METHODS

Study Participants

To reduce the considerable amount of acute health care resource use for asthma, a national asthma program was initiated in Singapore in 2000. The national disease management program identifies adult patients with high-risk asthma who were treated at EDs or specialist outpatient clinics in all 5 public sector general hospitals, covering 80% of hospitalizations in the country. In Singapore, primary health care is generally kept easily accessible and affordable. Low-income patients can receive highly subsidized ambulatory care from public sector community-based and hospital-based clinics, and hospitalization costs for major diseases are financed through a sophisticated national system of medical savings and insurance.⁴²

The asthma management program provides uniform, structured, continuous care for patients in ambulatory asthma care facilities by using evidence-based care paths for clinical decision making, patient education and training in self-management plans, asthma care nurses and case manager support, and regular reviews in specialist asthma clinics. These systemic measures aim to reduce excess β -agonist use, increase appropriate anti-inflammatory treatment, improve therapeutic adherence, enable patients to implement better self-care, and streamline all processes of care, including metered-dose inhaler instruction, prescription of spacers, peak flow meter monitoring, and written action plans according to a national asthma guideline based on Global Initiative for Asthma (GINA) consensus statements.⁴³ The program provides universal access for patients to be enrolled, regardless of ability to pay, and liberally offers large subsidies to patients for the purchase of expensive new drugs. In-hospital care for asthmatic patients in public sector hospitals is also subsidized, up to 75% or 100% for poor income or indigent patients.

In this program, an open-ended cohort of all adult patients with moderate-to-severe asthma were enrolled between January 1, 2000, and December 31, 2003. We analyzed data available for patients 20 years and older who had asthma diagnosed and evaluated by attending respiratory physicians using established clinical and GINA guidelines, who were Singapore citizens and permanent residents eligible for national health care financing benefits, and who experienced at least 1 severe acute exacerbation that required urgent treatment with wet nebulization of inhalational drugs in the past 6 months. Patients with primary chronic obstructive pulmonary disease were excluded.

Data Collection and Measurements

Dedicated asthma care nurses conducted baseline interviews and assessments in all languages on patients at enrollment. Each patient was given appointments for routine follow-up and medical reviews at varying intervals as determined by individual physician evaluation of the patient's status. Baseline and follow-up assessments were performed using structured interview questionnaire and clinical examination formats. At the baseline interview, demographic information

was collected on patient sex, age, and ethnicity. Socioeconomic status and financial ability to pay for asthma care were evaluated using the record of the patient's registration for the drug subsidy program.

Baseline asthma status and severity was evaluated by information on asthma duration in years and daytime and nighttime symptom frequency, activity restrictions, absence from work or school, long-term use of systemic corticosteroids, frequency of urgent nebulization, and ED visits or hospitalizations and history of endotracheal intubation during the previous 12 months. These markers of asthma severity were used to classify patients according to the GINA steps for recommended therapy for (1) intermittent, (2) mild persistent, (3) moderate persistent, and (4) severe persistent asthma.

Comorbid conditions were reported by patients as present or absent, including chronic sinusitis, gastroesophageal reflux disease, diabetes mellitus, ischemic heart disease, congestive heart failure, and chronic bronchitis. Data were also collected on known sensitization and environmental (allergenic and nonallergenic) triggers and aggravating factors, including current smoking, respiratory tract infections, house dust, animal furs, danders, food, and others.

At the baseline visit, nurses also evaluated patient adherence to treatment and self-management tasks. Self-management skills included evaluation of the patient's inhaler technique using a checklist of the criteria of good performance. Continuity of care was measured by tracking whether the patient had regularly attended or defaulted on scheduled follow-up appointments. Outcome data were collected on acute asthma-related health care resource utilization occurring during the intervals between follow-up visits, including the dates of events that included unscheduled visits to a physician at an ambulatory asthma facility other than an ED for worsening asthma symptoms resulting in urgent nebulization, ED visits, and hospitalizations.

Statistical Analysis

We used Cox proportional hazards regression modeling to identify factors independently associated with acute resource use. Events were censored on the dates of outcome events of interest (unscheduled physician visits, ED visits, or hospital admissions) or on December 31, 2003, or for losses to follow-up (participants for whom the outcome event status was unknown) at the date of the last follow-up visit. Time to first event after enrollment was modeled with covariate adjustment for severity of chronic asthma and other significant variables. Results of individual risk factors of interest are given in bivariate analyses of unadjusted hazard ratios (HRs) and in multivariate analyses of HRs adjusted for significant covariates. Because of the large number of variables available, forward stepwise selection regression modeling was performed. All the variables found to be significant in bivariate analyses at $P < .15$ were considered candidate variables for multivariate analysis and were entered in the regression model. Insignificant variables ($P < .10$) were progressively omitted until satisfactory models were found that explained

acute resource use. The final model, adjusted for severity status and other variables, was evaluated for multicollinearity. Each omitted variable was added one at a time to evaluate whether this had any effect on the coefficients and fit of the final model. Adequacy of the fit was evaluated by estimating the deviance and the Hosmer-Lemeshow statistic. All the analyses used 2-tailed significance levels of $P < .05$ and were conducted using a statistical software program (SPSS version 9.0; SPSS Inc, Chicago, IL). Data were analyzed for 1,677 asthmatic patients in the program, excluding 62 patients of other ethnicities (Eurasians, Thais, Myamanese, etc) and 4 patients with missing dates of birth and other data or duplicate records.

RESULTS

Cohort Description

The mean age of the patients was 44.3 years (range, 20–88 years), and 52.5% were women (Table 1). The ethnic composition was as follows: Chinese, 53.1%; Malays, 24.7%; and Indians, 22.2%. Two thirds of the patients had had asthma for more than 10 years (mean, 17.4 years); three quarters were classified as moderate to severe persistent asthma. More than a quarter of the patients were found to have poor inhaler technique or poor treatment adherence, and 21.8% were current smokers.

Patients were followed up for a mean of 8.8 months (median, 7.0 months). During follow-up, 382 patients reported at least 1 unscheduled physician visit (22.6%), 196 had at least 1 ED visit (11.7%), and 169 had at least 1 hospital admission (10.1%). The mean time to the first unscheduled physician visit was 7.0 months (median, 4.6 months), to the first ED visit was 7.9 months (median, 5.6 months), and to the first hospitalization was 8.1 months (median, 5.8 months).

Clinical Risk Factors

In bivariate analyses, markers of asthma severity were significantly associated with acute resource use: unscheduled physician visits (Table 2), ED visits (Table 3), and hospitalizations (Table 4). However, in multivariate analyses, functional measures of asthma severity, rather than symptom frequency measures, were significantly associated with acute resource use. Absence from work or school was significantly associated with all acute resource use, and activity restriction was associated with unscheduled physician visits and ED visits. Also, more frequent nebulization was significantly associated with increased risk of all acute resource use; previous ED visits were associated with unscheduled physician visits and ED visits.

In bivariate and multivariate analyses, Malay and Indian ethnicities were significantly associated with all acute resource use. After controlling for asthma severity and other covariates, Indian ethnicity was associated with increased risk of unscheduled physician visits (HR, 1.32; 95% confidence interval [CI], 1.03–1.70), ED visits (HR, 1.61; 95% CI, 1.12–2.32), and hospitalizations (HR, 1.49; 95% CI, 1.03–2.16). Malay ethnicity was significantly associated with in-

Table 1. Characteristics of 1,677 Asthmatic Patients in the Study Cohort*

Characteristic	Value
Female sex	880 (52.5)
Ethnicity	
Chinese	891 (53.1)
Malay	414 (24.7)
Indian	372 (22.2)
Financial subsidy for drugs	681 (40.6)
Age, mean $\pm$ SD (range), y	44.3 $\pm$ 16.3 (20–88)
Asthma duration, mean $\pm$ SD (range), y	17.4 $\pm$ 13.7 (1–70)
Asthma duration, y	
<10	524 (31.2)
10–29	797 (47.5)
$\geq$ 30	356 (21.2)
Days with wheeze/cough/shortness of breath	
None	176 (10.5)
1–2 times per month	193 (11.5)
1–2 times per week	433 (25.8)
$\geq$ 3 times per week	875 (52.2)
Nights with wheeze/cough/shortness of breath	
None	293 (17.5)
1–2 times per month	179 (10.7)
1–2 times per week	367 (21.9)
$\geq$ 3 times per week	838 (49.9)
Activity restriction	
None	744 (44.4)
1–2 times per month	196 (11.7)
1–2 times per week	204 (12.2)
$\geq$ 3 times per week	533 (31.8)
Absent from work or school	
None	577 (34.4)
1–2 times a month	305 (18.2)
1–2 times a week	175 (10.4)
$\geq$ 3 times a week	58 (3.5)
Not applicable (housewives)	562 (33.5)
FEV ₁ , % predicted (n = 984)	
$\geq$ 75	472 (48.0)
50–74	362 (36.8)
<50	150 (15.2)
Intubation in the past year	118 (7.0)
GINA classification	
Intermittent	148 (8.8)
Mild persistent	291 (17.4)
Moderate persistent	658 (39.2)
Severe persistent	580 (34.6)
Long-term oral corticosteroid therapy	58 (3.5)
No. of nebulizations in the past year	
0	483 (28.8)
1–5	874 (52.1)
$\geq$ 6	320 (19.1)
Medical comorbidity	379 (22.6)
Current smoking	365 (21.8)
Atopy	837 (49.9)
No. of triggers	
0–1	421 (25.1)
2–4	914 (54.5)
5–10	342 (20.4)
Poor treatment adherence	467 (27.8)
Inhaler technique	
Good	371 (22.1)
Satisfactory	840 (50.1)
Poor	466 (27.8)
Defaulted treatment	251 (15.0)

Abbreviations: FEV₁, forced expiratory volume in 1 second; GINA, Global Initiative for Asthma.

* Data are given as number (percentage) except where indicated otherwise.

Table 2. Factors Associated With Unscheduled Physician Visits for Urgent Nebulization in 1,677 Asthmatic Patients

	Crude		Adjusted*	
	P value	HR (95% CI)	P value†	HR (95% CI)
Male sex	.02	1.27 (1.04–1.55)	NA	NA
Age (reference: ≥65 y)	.047			
20–34 y	.049	1.42 (1.00–2.01)	NA	NA
35–64 y	.54	1.11 (0.80–1.54)	NA	NA
Ethnicity (reference: Chinese)				
Malay	.03	1.32 (1.03–1.69)	.04	1.30 (1.01–1.68)
Indian	.03	1.33 (1.04–1.70)	.03	1.32 (1.03–1.70)
Financial subsidy for drugs	.006	1.57 (1.14–2.17)	NA	NA
Asthma duration (reference: <10 y)	.35			
10–29 y	.33	1.12 (0.891–1.42)	NA	NA
≥30 y	.66	0.94 (0.711–1.25)	NA	NA
Days with wheeze/cough/breathlessness				
None	NA	NA	NA	NA
1–2 times per month	.19	1.41 (0.84–2.34)	NA	NA
1–2 times per week	.008	1.81 (1.17–2.80)	NA	NA
≥3 times per week	.02	1.62 (1.07–2.45)	NA	NA
Nights with wheeze/cough/breathlessness				
None	NA	NA	NA	NA
1–2 times per month	.16	1.37 (0.892–1.3)	NA	NA
1–2 times per week	.003	1.67 (1.192–3.5)	NA	NA
≥3 times per week	.003	1.56 (1.16–2.11)	NA	NA
Absent from work or school (reference: none)				
1–2 times a month	.20	1.22 (0.90–1.64)	.89	1.02 (0.75–1.40)
1–2 times a week	<.001	2.01 (1.43–2.83)	.04	1.44 (1.01–2.05)
≥3 times a week	.001	2.25 (1.39–3.63)	.11	1.52 (0.91–2.52)
Not applicable (housewives)	.96	0.99 (0.77–1.28)	.59	0.93 (0.71–1.22)
Restriction of activities (reference: none)				
1–2 times per month	.001	1.69 (1.25–2.29)	.005	1.55 (1.14–2.12)
1–2 times per week	.03	1.41 (1.04–1.91)	.02	1.47 (1.07–2.03)
≥3 times per week	.87	1.02 (0.80–1.30)	.051	1.32 (1.00–1.76)
GINA classification (reference: intermittent)				
Mild persistent	.44	1.21 (0.74–2.00)	NA	NA
Moderate persistent	.08	1.51 (0.95–2.38)	NA	NA
Severe persistent	.05	1.57 (0.99–2.47)	NA	NA
No. of urgent nebulizations in the past year				
1–5	<.001	1.77 (1.34–2.35)	.008	1.47 (1.11–1.96)
≥6	<.001	3.24 (2.40–4.37)	<.001	2.72 (2.01–3.68)
≥1 ED visits in the past year	.07	1.49 (0.97–2.28)	<.001	1.67 (1.28–2.19)
Hospitalization(s) in the past year	<.001	1.66 (1.35–2.05)	NA	NA
Intubation(s) in the past year	.03	1.43 (1.05–1.95)	NA	NA
Long-term oral corticosteroid therapy	.18	1.34 (0.88–2.04)	NA	NA
Medical comorbidity	.02	1.31 (1.05–1.64)	NA	NA
Smoking	<.001	1.59 (1.26–2.01)	.008	1.38 (1.09–1.76)
Atopy	.17	1.15 (0.94–1.41)	NA	NA
No. of triggers (reference: 0–1)				
2–4	.001	1.55 (1.19–2.02)	NA	NA
5–10	<.001	1.96 (1.44–2.66)	NA	NA
Inhaler technique (reference: good)				
Fair	.37	1.12 (0.87–1.43)	NA	NA
Poor	.77	1.04 (0.79–1.37)	NA	NA
Poor treatment adherence	.27	1.13 (0.91–1.41)	NA	NA
Defaulted follow-up visits	<.001	1.89 (1.41–2.54)	.01	1.47 (1.08–2.00)

Abbreviations: CI, confidence interval; ED, emergency department; GINA, Global Initiative for Asthma; HR, hazard ratio; NA, not applicable.

* Estimated from the forward stepwise selection model, with $P = .20$ for entry and $P = .10$ for removal from the model. Model fit: $-2 \log$ likelihood, 4833.6; $\chi^2_{13} = 174.6$; $P < .001$.

† Based on the Wald statistic.

Table 3. Factors Associated With Emergency Department Visits in 1,677 Asthmatic Patients

	Crude		Adjusted*	
	P value	HR (95% CI)	P value†	HR (95% CI)
Male sex	.03	1.36 (1.031.80)	.005	1.58 (1.15–2.17)
Age (reference: ≥65 y)	.052			
20–34 y	.48	1.17 (0.751.83)	NA	NA
35–64 y	.31	0.80 (0.521.23)	NA	NA
Ethnicity (reference: Chinese)				
Malay	.005	1.62 (1.162.26)	.02	1.55 (1.09–2.19)
Indian	.009	1.58 (1.122.24)	.009	1.61 (1.12–2.32)
Financial subsidy for drugs	.004	2.10 (1.263.51)	NA	NA
Asthma duration (reference: <10 y)				
10–29 y	.70	0.94 (0.681.29)	NA	NA
≥30 y	.57	0.89 (0.611.32)	NA	NA
Days with wheeze/cough/breathlessness				
None	NA	NA	NA	NA
1–2 times per month	.29	1.46 (0.72–2.93)	NA	NA
1–2 times per week	.05	1.82 (0.99–3.33)	NA	NA
≥3 times per week	.23	1.42 (0.80–2.52)	NA	NA
Nights with wheeze/cough/breathlessness				
None	NA	NA	NA	NA
1–2 times per month	.84	1.06 (0.58–1.94)	NA	NA
1–2 times per week	.29	1.28 (0.81–2.01)	NA	NA
≥3 times per week	.30	1.23 (0.83–1.83)	NA	NA
Absent from work or school (reference: none)				
1–2 times a month	.01	1.81 (1.15–2.83)	.10	1.48 (0.93–2.35)
1–2 times a week	.001	2.43 (1.45–4.07)	.15	1.49 (0.87–2.57)
≥3 times a week	<.001	4.48 (2.43–8.28)	.002	2.74 (1.43–5.26)
Not applicable (housewives)	.01	1.63 (1.11–2.39)	0.013	1.69 (1.12–2.55)
Restriction of activities (reference: none)				
1–2 times per month	.008	1.77 (1.16–2.69)	.051	1.56 (0.99–2.44)
1–2 times per week	.03	1.61 (1.06–2.44)	.026	1.64 (1.06–2.55)
≥3 times per week	.65	1.08 (0.77–1.53)	.32	1.23 (0.82–1.84)
GINA classification (reference: intermittent)				
Mild persistent	.68	1.15 (0.59–2.23)	NA	NA
Moderate persistent	.52	1.22 (0.66–2.24)	NA	NA
Severe persistent	.44	1.27 (0.69–2.34)	NA	NA
No. of urgent nebulizations in the past year				
1–5	<.001	2.09 (1.39–3.14)	.02	1.65 (1.09–2.50)
≥6	<.001	3.09 (2.00–4.79)	<.001	2.39 (1.53–3.75)
≥1 ED visits in the past year	<.001	2.35 (1.55–3.58)	<.001	2.24 (1.45–3.45)
Hospitalization(s) in the past year	<.001	2.04 (1.51–2.77)	NA	NA
Intubation(s) in the past year	.04	1.55 (1.02–2.36)	NA	NA
Long-term oral corticosteroid therapy	.83	0.93 (0.47–1.82)	NA	NA
Medical comorbidity	.53	1.11 (0.80–1.52)	NA	NA
Smoking	.001	1.69 (1.22–2.32)	NA	NA
Atopy	.38	1.13 (0.86–1.50)	NA	NA
No. of triggers (reference: 0–1)				
2–4	.008	1.65 (1.14–2.41)	NA	NA
5–10	.007	1.83 (1.18–2.85)	NA	NA
Inhaler technique (reference: good)				
Fair	.30	1.21 (0.84–1.74)	.32	1.29 (0.78–2.15)
Poor	.06	1.45 (0.99–2.13)	.03	1.86 (1.05–3.30)
Poor treatment adherence	.20	1.22 (0.90–1.65)	NA	NA
Defaulted follow-up visits	<.001	2.86 (1.99–4.12)	<.001	2.35 (1.59–3.45)

Abbreviations: CI, confidence interval; ED, emergency department; GINA, Global Initiative for Asthma; HR, hazard ratio; NA, not applicable.

* Estimated from the forward stepwise selection model, with $P = .20$ for entry and $P = .10$ for removal from the model. Model fit: $-2 \log$ likelihood, 2477.6; $\chi^2_{19} = 136.6$; $P < .001$.

† Based on the Wald statistic.

Table 4. Factors Associated With Hospitalizations in 1,677 Asthmatic Patients

	Crude		Adjusted*	
	P value	HR (95% CI)	P value†	HR (95% CI)
Male sex	.65	0.93 (0.69–1.26)	NA	NA
Age (reference: ≥65 y)	.26			
20–34 y	.13	0.69 (0.43–1.11)	NA	NA
35–64 y	.13	0.72 (0.48–1.10)	NA	NA
Ethnicity (reference: Chinese)				
Malay	.09	1.37 (0.94–1.99)	.27	1.24 (0.85–1.83)
Indian	.007	1.64 (1.14–2.35)	.04	1.49 (1.03–2.16)
Financial subsidy for drugs	.10	1.51 (0.92–2.46)	NA	NA
Asthma duration (reference: <10 y)	.59			
10–29 y	.49	0.89 (0.63–1.25)	NA	NA
≥30 y	.32	0.81 (0.53–1.23)	NA	NA
Days with wheeze/cough/breathlessness				
None	NA	NA	NA	NA
1–2 times per month	.06	2.19 (0.95–5.05)	NA	NA
1–2 times per week	.01	2.60 (1.23–5.50)	NA	NA
≥3 times per week	.04	2.12 (1.03–4.36)	NA	NA
Nights with wheeze/cough/breathlessness				
None	NA	NA	NA	NA
1–2 times per month	.84	0.94 (0.50–1.75)	NA	NA
1–2 times per week	.88	0.96 (0.60–1.56)	NA	NA
≥3 times per week	.91	1.02 (0.69–1.53)	NA	NA
Absent from work or school (reference: none)				
1–2 times a month	.57	1.17 (0.69–1.98)	.91	0.97 (0.56–1.66)
1–2 times a week	.03	1.94 (1.08–3.47)	.22	1.46 (0.80–2.64)
≥3 times a week	.000	4.53 (2.39–8.58)	.002	2.95 (1.51–5.77)
Not applicable (housewives)	.004	1.81 (1.21–2.71)	.04	1.54 (1.02–2.33)
Restriction of activities (reference: none)				
1–2 times per month	.07	1.49 (0.97–2.30)	NA	NA
1–2 times per week	.97	0.99 (0.62–1.58)	NA	NA
≥3 times per week	.09	0.72 (0.50–1.05)	NA	NA
GINA classification (reference: intermittent)				
Mild persistent	.89	1.05 (0.50–2.20)	NA	NA
Moderate persistent	.34	1.38 (0.71–2.68)	NA	NA
Severe persistent	.44	1.30 (0.67–2.54)	NA	NA
No. of urgent nebulizations in the past year	.02			
1–5	.01	1.76 (1.15–2.70)	.22	1.32 (0.85–2.06)
≥6	<.001	2.99 (1.90–4.70)	.006	1.92 (1.20–3.07)
≥1 ED visits in the past year	.004	1.84 (1.21–2.80)	NA	NA
Hospitalization(s) in the past year	<.001	3.67 (2.52–5.35)	<.001	2.69 (1.85–3.99)
Intubation(s) in the past year	.002	1.99 (1.30–3.04)	NA	NA
Long-term oral corticosteroid therapy	.34	1.35 (0.73–2.49)	NA	NA
Medical comorbidity	.009	1.53 (1.11–2.12)	NA	NA
Smoking	.09	1.37 (0.95–1.97)	NA	NA
Atopy	.38	0.87 (0.64–1.18)	NA	NA
Number of triggers (reference: 0–1)	.09			
2–4	.05	1.48 (1.00–2.18)	NA	NA
5–10	.05	1.59 (1.00–2.55)	NA	NA
Inhaler technique (reference: good)				
Fair	.04	0.69 (0.48–0.99)	NA	NA
Poor	.33	0.82 (0.56–1.21)	NA	NA
Poor treatment adherence	.61	1.09 (0.78–1.52)	NA	NA
Defaulted follow-up visits	.003	1.96 (1.27–3.05)	.02	1.74 (1.09–2.76)

Abbreviations: CI, confidence interval; ED, emergency department; GINA, Global Initiative for Asthma; HR, hazard ratio; NA, not applicable.

* Estimated from the forward stepwise selection model, with $P = .20$ for entry and $P = .10$ for removal from the model. Model fit: $-2 \log$ likelihood, 2117.0; $\chi^2_{11} = 125.9$; $P < .001$.

† Based on the Wald statistic.

Table 5. Ethnic Comparisons of Asthma-Related Characteristics and Behaviors

	Participants, %			χ^2	df	P value
	Chinese	Malay	Indian			
Age, y				29.3	4	<.001
20–34	31.5	33.3	35.2			
35–64	52.4	59.4	57.0			
≥65	16.0	7.2	7.8			
Male sex	52.3	42.0	42.2	17.4	2	<.001
Financial drug subsidy	79.8	75.1	74.2	6.34	2	.04
Asthma duration, y				9.75	4	.045
<10	32.1	29.7	30.9			
10–29	44.3	51.0	51.3			
≥30	23.6	19.3	17.7			
Days with wheeze/cough/shortness of breath				15.2	6	.02
None	10.9	11.8	8.1			
1–2 times per month	12.8	8.9	11.3			
1–2 times per week	27.9	22.9	23.9			
≥3 times per week	48.4	56.3	56.7			
Nights with wheeze/cough/shortness of breath				21.5	6	.002
None	19.9	12.8	16.9			
1–2 times per month	11.3	10.1	9.7			
1–2 times per week	23.5	18.8	21.5			
≥3 times per week	45.3	58.2	51.9			
Absent from work or school (reference: none)				30.8	8	<.001
None	36.8	26.8	37.1			
1–2 times a month	16.5	21.3	18.8			
1–2 times a week	9.2	12.6	11.0			
≥3 times a week	2.2	4.1	5.6			
Not applicable (housewives)	35.2	35.3	27.4			
Restriction of activities (reference: none)				20.2	6	.003
None	47.8	38.9	42.2			
1–2 times per month	11.9	8.9	14.2			
1–2 times per week	11.2	13.5	12.9			
≥3 times per week	29.1	38.6	30.6			
GINA classification				26.4	6	<.001
Intermittent	9.9	7.0	8.3			
Mild persistent	21.2	12.6	13.4			
Moderate persistent	36.7	41.3	43.0			
Severe persistent	32.2	39.1	35.2			
No. of urgent nebulizations in the past year				19.5	4	.001
0	31.6	24.9	26.3			
1–5	52.1	55.8	48.1			
≥6	16.3	19.3	25.5			
≥1 ED visits in the past year	NA	NA	NA	NA	NA	NA
Hospitalization(s) in the past year	48.3	59.4	54.0	14.7	2	.001
Intubation(s) in the past year	7.1	8.2	5.6	1.98	2	.37
Long-term oral corticosteroid therapy	4.0	2.9	2.7	1.95	2	.38
Medical comorbidity	21.7	25.1	22.0	2.02	2	.36
Smoking	21.8	22.9	20.4	0.72	3	.69
Atopy	49.8	49.0	51.1	0.33	2	.85
No. of triggers				16.1	4	.003
0–1	27.8	20.8	23.4			
2–4	53.2	60.4	51.1			
5–10	19.0	18.8	25.5			
Inhaler technique				10.4	4	.04
Good	24.5	16.7	22.6			
Fair	48.1	54.6	49.7			
Poor	27.4	28.7	27.7			
Poor treatment adherence	26.8	31.6	26.1	4.01	2	.13
Defaulted follow-up visits	11.7	19.3	18.0	16.5	2	.001

Abbreviations: ED, emergency department; GINA, Global Initiative for Asthma; NA, not applicable.

creased risk of unscheduled physician visits (HR, 1.30; 95% CI, 1.01–1.68) and ED visits (HR, 1.55; 95% CI, 1.09–2.19).

In bivariate analyses, smokers were more likely to experience an increased risk of unscheduled physician visits and ED visits. However, in multivariate analyses, smoking was found to remain independently associated only with unscheduled physician visits (HR, 1.38; 95% CI, 1.09–1.76). Among self-care behaviors, default of follow-up was consistently associated with increased risk of all acute resource utilization in bivariate and multivariate analyses: unscheduled physician visits (HR, 1.47; 95% CI, 1.08–2.00), ED visits (HR, 2.35; 95% CI, 1.59–3.45), and hospitalizations (HR, 1.74; 95% CI, 1.09–2.76). Also, in multivariate analyses, poor inhaler technique (HR, 1.86; 95% CI, 1.05–3.30) and male sex (HR, 1.58; 95% CI, 1.15–2.17) were found to be independently associated with ED visit. Although in bivariate analyses increasing numbers of reported triggers of asthma and being registered for drug subsidy were associated with increased likelihood of use of all acute resources, they were not found to be independently associated in multivariate analyses.

DISCUSSION

The present findings confirm the previously reported^{38,40} higher risk of morbidity, resulting in increased health care resource use among Malay and Indian adults with asthma. Other population studies^{13–25} have also reported African Americans with higher hospitalization rates for asthma. Disease severity, socioeconomic status, and health care access, however, may confound the relationship between ethnicity and hospitalization. The present data indicate that these factors were unlikely to confound the observed differences. Although Malay and Indian patients had more severe asthma based on symptoms and on functional and service utilization measures of asthma severity (Table 5), these factors did not completely account for ethnic disparity in acute resource use.

The link between ethnicity and acute resource use may also be confounded by income. Previous studies have indicated an association between lower household income and increased hospitalization risk,^{14–26} which is linked to inadequate health care access. Individuals with low income are more likely to have difficulty paying for physician bills or prescription drugs⁴⁴ and to have no usual source of outpatient asthma care after hospitalization.²⁶ In Singapore, Malays and Indians have lower average household incomes than Chinese people (Singapore Census Report 2000). However, in this national asthma management program, all the participants have easy access to subsidized care in ambulatory primary care and hospital-based clinics and national medical saving and insurance for hospitalization; subsidy for expensive new prescription drugs further removes financial barriers to access to asthma care. Thus, the study was performed in a setting that effectively rules out low income and access to care as factors in obtaining needed treatment through the program. The present findings are in agreement with other studies that reported higher hospitalization rates after controlling for in-

come^{15–17,21,22} or that were performed in similar settings with access to care through Medicaid or managed care.^{20,24,25}

The present finding regarding default of follow-up highlights the importance of continuity of care and the physician-patient relationship in determining asthma outcomes. Previous studies³⁴ have shown that acute resource utilization is less frequent among patients who reported having a primary physician in charge of their asthma management. Patients with no regular source of care had significantly worse asthma control,²⁶ whereas those with a usual source of care were more likely to receive inhaled corticosteroids, spacers, and peak flow meters.²⁶ In the present study, patients in the program have a regular health care provider and are, hence, expected to have optimal structure for patient-provider contact and evidence-based management. They were also encouraged to use the ambulatory care services of their designated physician rather than the ED to treat acute exacerbations. This may suggest that the responsible factors for continuity of care may be related to culture and behavior^{44–47} rather than to structure of care. Further studies that investigate the causes of such lack of continuity should address psychosocial elements of asthma intervention and care, such as dissatisfaction with care and depression, and avoidance coping.³¹

We found significant variation in inhaler techniques that was associated with subsequent increased risk of ED visits. This reflection of poor patient self-management is consistent with review findings⁴³ that identify noncompliance with self-management skills as an element of interventions that is associated with asthma-related ED visits. We also show that smoking was associated with increased risk of unscheduled physician visits. This finding is consistent with previous findings^{36,37} that cigarette smoking is associated with poor symptom control and impaired therapeutic responses to corticosteroids. We found that male sex was significantly associated only with increased risk of ED visits. However, sex has been found to be inconsistently related to health care resource use.^{4–6,8–11,27}

The large sample size is a strength of this study. However, we should be cautious in generalizing the findings to the overall population of asthmatic patients, such as those in primary care clinics. Another limitation is the self-report of health care utilization. The reliability of self-reports of health care service utilization has been investigated and found to be substantially reliable for hospital admissions and physician visits, although not as much for ED visits.⁴⁸

In conclusion, these results demonstrated that in addition to markers of asthma severity, ethnicity, discontinuity of care, poor self-management skills, and smoking are significant predictors of acute resource utilization among adults with asthma. These represent high-risk groups for targeted intervention and potentially modifiable elements of asthma intervention and care for improving outcomes.

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