Different Severity and Severity Predictors in Early-Onset and Late-Onset Asthma: A Taiwanese Population-Based Study

Tsung-Ju Wu^{a, d} Bing-Yu Chen^c Yungling Leo Lee^b Tzuen-Ren Hsiue^e
Chang-Fu Wu^a Yue Leon Guo^{a, c}

^aInstitute of Occupational Medicine and Industrial Hygiene, and ^bInstitute of Epidemiology and Preventive Medicine, National Taiwan University, ^cDepartment of Environmental and Occupational Medicine, National Taiwan University (NTU) College of Medicine and NTU Hospital, Taipei, ^dDivision of Chest Medicine, Department of Internal Medicine, Kaohsiung Municipal Min-Sheng Hospital, Kaohsiung, and ^eDivision of Chest Medicine, Department of Internal Medicine, National Cheng Kung University Hospital, Medical College, National Cheng Kung University, Tainan, Taiwan, ROC

Key Words

Adult · Asthma · Asthma phenotype · Atopic disease ·
Bronchodilator agents · Dampness · Disease severity

Abstract

Background: Late-onset asthma has been shown to be more severe than early-onset asthma in clinic-based studies. However, population-based studies are scarce, and the predictors of severity have been less studied. **Objectives:** To determine asthma severity and severity predictors regarding age at onset. **Methods:** A cross-sectional questionnaire survey was conducted among parents of children from 94 schools in Taiwan in 2004. Asthma severity was defined as short-acting β_2 -agonist (SABA), inhaled corticosteroid (ICS) and health care use in the last year. Information on age at onset, demographics, heredity and home exposure was collected. Ordered logistic or logistic regression was used for determining the associations between risk factors and severity. **Results:** Participants aged 26–50 years were included, resulting in 21,057 (67.8%) participants. Among them, 449 reported ever having had physician-diagnosed asthma, and 381 of those subjects answered the question on age at asthma on-

set. The risks of rescue SABA, ICS and health care use were generally higher among late-onset (13–50 years) than early-onset (0–12 years) asthmatics. Use of SABA and health care increased from childhood-onset, adolescent- or young adult-onset to adult-onset asthma. Allergic rhinitis was positively associated with SABA use (OR, 9.08; 95% CI, 1.06–77.99) and ICS use (OR, 5.08; 95% CI, 1.47–17.52) in early-onset asthma. Dehumidifier use was negatively associated with SABA use (OR, 0.50; 95% CI, 0.29–0.87) and ICS use (OR, 0.38; 95% CI, 0.19–0.78) in late-onset asthma. **Conclusions:** In adults, late-onset asthma was more severe than early-onset asthma. Severity, as indicated by SABA and ICS use, was positively associated with allergic rhinitis in early-onset asthma and negatively associated with dehumidifier use in late-onset asthma.

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Introduction

Previous clinic-based studies have shown that patients with late-onset asthma have persistent airflow limitation [1], low lung function [2] and rapid decline of lung func-

tion [3]. In a phenotype classification study [4], late-onset asthma has been associated with less atopy and more severe asthma. These findings highlight greater severity and a nonallergic mechanism in late-onset asthma. Late-onset wheeze, as a surrogate measure of asthma, is likely to account for over half of adult wheeze [5, 6]. However, to our knowledge, there has been no population-based study on different severity and predictors of severity between late-onset and early-onset asthma.

There has been no consensus on epidemiological measurement of asthma severity. In clinical practice, two widely accepted guidelines, namely National Asthma Education and Prevention Program (NAEPP) guidelines and Global Initiative for Asthma (GINA) guidelines, utilize lung function, rescue use of short-acting β_2 -agonist (SABA) and other medications to maintain control as the determinants of asthma severity [7, 8]. However, lung function does not correlate with asthma symptoms [9], or predict health-related quality of life at any level of severity [10]. In addition to the severity definitions mentioned above, several groups suggested the inclusion of health care use to account for severe asthma [11–13]. A composite of scores for asthma severity, including SABA use, inhaled corticosteroid (ICS) use and hospitalization, has been reported to predict clinical outcome well in population-based research [14]. Thus, the use of rescue SABA, ICS and health care could be a reliable surrogate marker of asthma severity.

A previous study in southern Taiwan has shown that both hereditary and environmental factors contribute to the occurrence of adult asthma [15]. We speculated that age at asthma onset, heredity and environmental exposure are important factors for asthma severity. As late-onset asthma is more severe than early-onset asthma in clinic-based studies, we tested the hypothesis whether late-onset asthma is more severe than early-onset asthma in a population-based study. Furthermore, we hypothesized that asthma severity – defined as the frequency of SABA, ICS and health care use – is associated with differential risk factors between early-onset and late-onset asthma.

Materials and Methods

Detailed methods have been described in a previous publication [15]. In brief, a cross-sectional self-administered questionnaire survey about respiratory health was sent through school children to their parents from 94 elementary and middle schools in 5 administrative districts of southern Taiwan in 2004 (fig. 1). In each school, random sampling of candidate participants from each grade stratification was conducted. The study protocol was approved by the Institutional Review Board at the University Hospital. Each participant provided informed consent.

The definition of asthma was a positive response to the question: ‘Have you ever had asthma confirmed by a doctor?’ If the answer was yes, he/she would be further asked: ‘At what age did it start?’

Environmental and Hereditary Determinants

Environmental factors included cockroaches, water damage, visible molds on walls, incense burning, perceived air pollution, pet ownership, dehumidifier use, carpet use, smoking and environmental tobacco smoke (ETS) exposure. Hereditary factors included parental asthma and personal atopy in terms of allergic rhinitis, allergic conjunctivitis, allergic eczema and urticaria. Sex, age, body mass index (BMI), education level and family income level were also included as possible confounders.

Study Subjects and Severity Measures

We included physician-diagnosed asthmatics aged 26–50 years. Subjects aged 26 years were the youngest parents in the sample; subjects aged over 50 years were not included because chronic obstructive pulmonary disease and heart failure are possible confounders in the elderly. The outcome measures were: frequency of SABA use in the past 12 months, classified on an ordinal scale as (1) none, (2) use during an episode of common cold, (3) less than once per month, (4) more than once per month but less than once per week, (5) more than once per week; ICS use in the past 12 months (yes/no); health care use, including emergency department visits or hospitalization due to asthma attack in the past 12 months (yes/no).

Statistical Analysis

Univariable analyses were used to determine associations between predictors and severity models of asthma. We created multivariable logistic or ordered logistic regression models containing all predictors of severity models of asthma. Reduced models were then created by removing exposure variables with $p > 0.15$ in the full models. The asthmatics were stratified by age at onset of 12 years for further analysis, as age at asthma onset (>12 or ≤ 12 years) identifies different phenotypes of asthma [2]. Stata 14.0 (StataCorp LP, College Station, Tex., USA) was used for analyses.

We used mixed models for possible random effects by district and school. SABA use was modeled as ordinal variables with proportional odds, i.e. having the same odds ratio for all adjoining combinations of 5 ordinal categories. ICS and health care use were modeled as dichotomized variables.

We developed a composite score modified by Eisner’s method for validation. Because we intended to evaluate asthma severity and chronic exposure to indoor environmental factors, we extended the usage period to the preceding 12 months. For a better response rate in a large cross-sectional survey, we did not include detailed medication items as Eisner’s score [14]. On the other hand, cromolyn/nedocromil and home nebulizers are seldom used for asthma in southern Taiwan. Thus, among 13 items of Eisner’s score, we have comparable items, including SABA use, ICS use, health care use, oral medication use and frequencies of asthma symptoms, but for the preceding 12 months. We further used these items to develop a modified Eisner score. In addition, we performed factor analysis to develop an index of severity based on extracted factors of SABA, ICS and health care use. A composite score for asthma severity was assigned to each asthmatic, and the influence of risk factor burden on the composite score was determined by ordered logistic regression.

Fig. 1. The 5 administrative districts of the study in southern Taiwan in 2004.

Results

Our study surveyed the parents of 35,682 school children. A total of 11,477 subjects were excluded due to inadequate demographic information or missing responses to the key question. Data from 24,205 subjects remained

satisfactory (67.8%). We enrolled physician-diagnosed asthmatics aged 26–50 years, and 449 asthmatics were identified among 21,057 subjects. The prevalence of physician-diagnosed adult asthma was 2.1% (449/21,057) in our study, which is comparable to a population-based survey in Taipei City in 1999 (2.4%) [16]. Table 1 shows

Table 1. Demographic characteristics of the population (n = 21,057)

Demographic factor	Physician-diagnosed asthma, n (%)			p
	no (n = 20,608)	yes (n = 449)		
		onset ≤12 years (n = 144)	onset >12 years (n = 237)	
Sex				0.3
Male	8,074 (39.2)	55 (38.2)	81 (34.2)	
Female	12,534 (60.8)	89 (61.8)	156 (65.8)	
Age, years	39.0±4.8	38.7±5.0	38.9±5.0	0.5
BMI	23.1±3.4	23.6±3.4	23.9±4.0	<0.001
Education				0.8
Middle school or less	5,680 (27.6)	27 (18.8)	61 (25.7)	
High school	10,358 (50.3)	74 (51.4)	122 (51.5)	
College or beyond	4,570 (22.2)	43 (29.9)	54 (22.8)	
Family income ^a				0.003
<13,300 USD	8,062 (39.1)	36 (25.0)	97 (40.9)	
13,300–33,000 USD	10,412 (50.5)	86 (59.7)	109 (46.0)	
>33,000 USD	2,134 (10.4)	22 (15.3)	31 (13.1)	

Among 21,057 subjects, 449 physician-diagnosed asthmatics were identified; 68 physician-diagnosed asthmatics who did not answer the question about age at onset were excluded from the analysis. Some percentages do not total 100 because of rounding. ^a p for trend ≤0.0167 (Bonferroni correction, for either asthmatics with asthma onset at ≤12 years vs. onset at >12 years, or asthmatics with asthma onset ≤12 years vs. subjects without asthma); p for trend >0.0167 (for asthmatics with asthma onset at >12 years vs. subjects without asthma).

the characteristics of the study subjects. There were significant differences between subjects with early-onset, late-onset and no asthma regarding BMI. There was a trend for higher family income in early-onset asthma compared with late-onset asthma subjects and those without asthma. Of the total physician-diagnosed asthmatics, 84.9% (381/449) revealed the age at onset and 62.2% (237/381) were 13 years or older at onset.

After adjustment, later-onset asthmatics still had greater severity in any of the severity models (SABA, ICS and health care use). The risks of using SABA and health care peak at the onset age of 26–50 years, whereas the risk of using ICS was generally higher in late-onset asthma compared with early-onset asthma (table 2). When mutual adjustment was applied, SABA use was associated positively with wall molds, allergic rhinitis and paternal and maternal asthma, and negatively with dehumidifier use. ICS use was associated positively with allergic rhinitis and negatively with dehumidifier use ($p \leq 0.15$; table 3).

While asthmatics were stratified by age at onset of 12 years, allergic rhinitis was a predictor of SABA and ICS

use for early-onset asthma, whereas dehumidifier use was a protective factor of SABA and ICS use for late-onset asthma (table 4).

In a validation model using a composite score as the severity outcome, only one factor was extracted by factor analysis. The factor loadings for SABA, ICS and health care use were 0.91, 0.92 and 0.45, respectively. The overall factor was thus considered as a ‘severity’ factor.

The Pearson correlation coefficients of SABA, ICS and health care use with the composite score modified by Eisner’s method were 0.83, 0.79 and 0.41, respectively. Furthermore, the correlation between the composite score developed by factor analysis and the modified Eisner score was good as well ($R = 0.87$).

When the composite scores – both modified Eisner’s score and the score developed by factor analysis – were used as the outcome variable in regression analysis, the risk factor (allergic rhinitis) and protective factor (dehumidifier use) acquired by these models were essentially the same in point estimates and statistical significance with the SABA use and the ICS use model.

Table 2. Odds ratios and adjusted odds ratios for SABA use, ICS use and health care use among asthmatics of different ages at asthma onset

Age at onset	Physician-diagnosed asthma (n = 449) ^a											
	SABA use				ICS use				health care use			
	OR	95% CI	aOR ^b	95% CI	OR	95% CI	aOR ^b	95% CI	OR	95% CI	aOR ^b	95% CI
0–12 years (144)	1.00	reference	1.00	reference	1.00	reference	1.00	reference	1.00	reference	1.00	reference
13–25 years (77)	2.35	1.30–4.24	2.24	1.19–4.24	2.53	1.31–4.87	2.79	1.33–5.84	2.20	0.67–7.20	1.94	0.56–6.65
26–50 years (160)	2.37	1.45–3.85	2.77	1.60–4.80	2.04	1.16–3.56	2.73	1.44–5.19	5.79	2.18–15.42	6.16	2.16–15.72

Figures in parentheses indicate number of asthmatics. aOR = Adjusted odds ratio; CI = confidence interval; OR = odds ratio. ^a Among 449 physician-diagnosed asthmatics, 381 subjects answered the question about age at onset. The total number in each model varies from 356 to 373 by models and risk factors due to missing data. ^b The ORs for age at onset were adjusted for sex, age, BMI, education level, family income level and the variables included in the reduced models of respective severity models.

Table 3. Associations of risk factors and severity models (SABA, ICS or health care use) among asthmatics

	Physician-diagnosed asthma (n = 449) ^a											
	SABA use				ICS use				health care use			
	OR	95% CI	aOR ^b	95% CI	OR	95% CI	aOR ^b	95% CI	OR	95% CI	aOR ^b	95% CI
<i>Environmental factor</i>												
Cockroaches at home	1.08	0.61–1.92	1.00	0.53–1.88	0.97	0.50–1.86	0.97	0.47–2.01	0.69	0.27–1.74	0.63	0.21–1.92
Water damage at home	0.96	0.50–1.83	0.65	0.31–1.33	0.90	0.43–1.87	0.70	0.31–1.59	1.12	0.42–3.03	0.95	0.27–3.31
Molds on walls at home	1.69 ^c	1.00–2.85	1.98 ^c	1.11–3.53	1.69 ^c	0.93–3.05	1.54	0.80–2.97	0.55	0.21–1.42	0.60	0.19–1.85
Incense burning at home	1.17	0.75–1.84	0.89	0.52–1.52	0.92	0.56–1.51	0.86	0.47–1.55	1.51	0.72–3.17	1.48	0.55–4.01
Perceived air pollution	1.10	0.70–1.72	1.00	0.61–1.65	1.19	0.71–2.00	1.33	0.74–2.40	1.03	0.49–2.18	1.06	0.43–2.61
Pets at home	1.05	0.67–1.65	1.11	0.67–1.83	1.23	0.72–2.08	1.32	0.74–2.36	1.37	0.64–2.91	1.62	0.63–4.12
Dehumidifier use at home	0.51 ^c	0.33–0.79	0.48 ^c	0.29–0.78	0.51 ^c	0.31–0.84	0.52 ^c	0.30–0.90	0.82	0.41–1.67	0.75	0.31–1.81
Carpet use at home	1.13	0.53–2.39	1.02	0.45–2.33	0.61	0.24–1.58	0.63	0.22–1.78	2.15	0.66–7.01	2.25	0.57–8.94
Smoking	1.28	0.81–2.03	1.26	0.68–2.32	0.90	0.53–1.55	1.04	0.51–2.12	0.94	0.43–2.04	0.96	0.33–2.83
ETS at home	1.38 ^c	0.89–2.13	1.17	0.70–1.97	1.20	0.74–1.95	1.31	0.74–2.30	0.78	0.38–1.60	0.54	0.21–1.42
<i>Hereditary factor</i>												
Allergic rhinitis	1.49 ^c	0.96–2.31	1.47 ^c	0.88–2.44	2.01 ^c	1.21–3.34	2.12 ^c	1.17–3.87	0.97	0.48–1.95	0.88	0.38–2.04
Allergic conjunctivitis	1.21	0.71–2.06	1.08	0.58–2.01	1.53	0.81–2.88	1.37	0.66–2.85	1.01	0.39–2.61	0.91	0.29–2.87
Atopic eczema	1.14	0.54–2.42	1.15	0.51–2.61	1.79	0.79–4.06	1.62	0.65–4.06	1.57	0.49–5.02	2.23	0.58–8.57
Urticaria	0.98	0.54–1.78	0.84	0.43–1.62	1.17	0.62–2.22	0.88	0.41–1.88	1.11	0.44–2.81	0.89	0.27–2.94
Asthma in father	1.37	0.73–2.56	1.70 ^c	0.85–3.39	0.95	0.46–1.95	1.02	0.45–2.31	1.01	0.37–2.75	1.13	0.37–3.46
Asthma in mother	1.85 ^c	1.08–3.17	1.70 ^c	0.94–3.08	1.34	0.71–2.54	1.02	0.51–2.07	0.95	0.38–2.38	0.72	0.24–2.11

aOR = Adjusted odds ratio; CI = confidence interval; OR = odds ratio. ^a The total number varies from 328 to 338 by models and risk factors due to missing data. ^b The odds ratios for environmental factors and hereditary factors were mutually adjusted respectively and adjusted for sex, age, BMI, education level and family income level. ^c Variables $p \leq 0.15$.

Discussion

Among adults, late-onset asthmatics had greater severity than early-onset asthmatics, as indicated by risks of SABA, ICS and health care use in this population-based study. Furthermore, SABA and health care use were found to be increased with later age at asthma onset,

namely adult onset (26–50 years) > adolescent or young adult onset (13–25 years) > childhood onset (0–12 years). More severe cases of early-onset asthma had allergic rhinitis as comorbidity, whereas dehumidifier use was associated with decreased severity.

In the current study, we used the age of 12 years as a cutoff, which was reported to be able to differentiate an

Table 4. Associations of risk factors and severity models (SABA or ICS use) among asthmatics, stratified by age at onset of 12 years

Risk factor	Early onset (n = 144)								Late onset (n = 237)							
	SABA use				ICS use				SABA use				ICS use			
	no	yes	aOR	95% CI	no	yes	aOR	95% CI	no	yes	aOR	95% CI	no	yes	aOR	95% CI
Wall molds																
No	82	27	1.00	reference	89	21	1.00	reference	102	82	1.00	reference	118	64	1.00	reference
Yes	17	10	3.58	0.73–17.60	19	8	1.58	0.45–5.53	21	25	1.16	0.59–2.28	26	20	1.46	0.64–3.33
Dehumidifier use																
No	36	18	1.00	reference	41	14	1.00	reference	42	50	1.00	reference	49	42	1.00	reference
Yes	68	20	0.64	0.19–2.21	72	16	0.73	0.26–2.03	83	59	0.50 ^a	0.29–0.87	98	43	0.38 ^a	0.19–0.78
Allergic rhinitis																
No	53	5	1.00	reference	54	4	1.00	reference	050	44	1.00	reference	63	31	1.00	reference
Yes	48	31	9.08 ^a	1.06–77.99	56	24	5.08 ^a	1.47–17.52	71	64	0.89	0.50–1.58	80	53	1.57	0.78–3.19
Asthma in father																
No	91	34	1.00	reference	97	28	1.00	reference	111	93	1.00	reference	129	73	1.00	reference
Yes	13	4	1.89	0.21–16.90	16	2	0.40	0.04–4.00	14	16	1.71	0.77–3.78	18	12	1.24	0.47–3.32
Asthma in mother																
No	94	30	1.00	reference	100	25	1.00	reference	106	84	1.00	reference	122	68	1.00	reference
Yes	10	8	3.30	0.54–20.07	13	5	1.19	0.29–4.90	19	25	1.95	0.98–3.88	25	17	1.14	0.48–2.71

The total number of asthmatics varies by models and risk factors due to missing data. No significant risk factor was identified in the health care use model. The odds ratios (aOR) were adjusted for sex, age, BMI, education level, family income level and the variables included in the reduced models. CI = Confidence interval. ^a Variables $p < 0.05$.

allergic phenotype from a more eosinophilic later-onset phenotype [2]. In addition, SABA, ICS and health care use were different between asthmatics with age at onset ≤ 12 years and those with age at onset > 12 years (online suppl. table 1; for all online suppl. material, see www.karger.com/doi/10.1159/000439310).

A concern is that among those using ICS very actively, the severity of asthma could have been masked by ICS, and the assessment of asthma severity could have been misclassified while a single severity indicator was used. When a composite score was used for severity assessment, the misclassification could be eliminated. In our study population, we further observed that none of the participants actively used ICS (> 3 months per year) and did not use SABA. This indicated that ICS and SABA were used in combination and both were related to the severity of asthma. This is supported by a good association between SABA and ICS use ($R^2 = 0.51$) and implies that even a single severity indicator was able to classify the asthma severity in our population.

In our study, the risks of rescue SABA use, ICS use and health care use were generally higher among late-onset asthmatics. Similarly, in several clinic-based studies which evaluated the severity of asthma in relation to age

at onset by spirometry, later onset of asthma was a risk factor of persistent airflow limitation [1], low lung function [2] and rapid decline of lung function [3]. In a longitudinal study, airflow limitation and the response to bronchodilator of asthmatics diagnosed at ages of 16–22 years were lower compared with the younger age groups [17]. In contrast, a clinic-based study showed a lower lung function in early-onset asthmatics relapsing in adulthood than in late-onset asthmatics and no significant difference between them regarding the risk of SABA use [18]. Relapse or persistence of childhood asthma was associated with lung function decline indicated by severity of airflow limitation [19]. As a result, compared to a population-based study, a clinic-based study which might include early-onset asthmatics with relapse or persistence in adulthood would show greater severity of early-onset asthma.

In this study, we observed the highest odds ratio of SABA and health care use in adult-onset asthma (onset ages of 26–50 years), which is consistent with a large clinic-based study [4]. In the latter study, late-onset asthmatics (mean onset age, 42 years) used more health care. They had sinus disease (63%) and gastroesophageal reflux (37%) as comorbid conditions, which was in turn associ-

ated with poor control of asthma. The number of comorbid conditions has been reported to be associated with asthma severity [20]. Since the current study was based on a questionnaire survey, only a limited number of comorbid conditions were investigated, including smoking, ETS exposure, allergic rhinitis and overweight (BMI >25). Allergic rhinitis and overweight were found to be more prevalent among later-onset asthmatics than early-onset asthmatics but without statistical significance (data not shown). On the other hand, a phenotype of poor response to medicines could also contribute to high risk of attacks. A higher odds ratio of ICS use was observed among late-onset asthmatics compared with early-onset asthmatics, which might highlight a phenotype of poor response to corticosteroids [21].

Indoor dampness-related microbes are associated with asthma-related symptoms in adults [22] and might favor the existence of dust mites and molds. On the other hand, dehumidifier use is negatively associated with airborne endotoxin [23], which has been associated with severity of nonatopic asthma and adult asthma [24]. In a study classifying asthma phenotypes, nonatopic asthma was more preponderant in late-onset asthma than early-onset asthma [4]. In our study, dehumidifier use was a protective factor only in late-onset asthma. We reasoned that the preponderance of nonatopy in late-onset asthma and a nonatopic mechanism could contribute to the severity in late-onset asthma. However, dehumidifier use could be related to a decrease in mold and therefore potentially affect asthma symptoms or severity through an atopic mechanism. However, allergy to common allergenic fungi in adult asthmatics was low (17%) [25]; thus, the effect of atopy could be small.

Allergic rhinitis is a predictor of greater severity of asthma when asthmatics were not stratified by age at onset [26, 27]. However, 2 longitudinal studies showed that childhood allergic rhinitis is associated with asthma persistence [28] and atopic asthma, but not nonatopic asthma in adulthood [29]. Atopy is preponderant in childhood asthma and could account for 60% of children with persistent wheezing at ages of 3 and 6 years [30]. In our study, allergic rhinitis was a predictor of greater severity only in early-onset asthma, and we reasoned that preponderance of atopy in early-onset asthma and an atopic mechanism could play a role in the severity of early-onset asthma in adulthood.

As we intended to assess the association of asthma severity and current exposure, we collected environmental determinants for the respondent's current experience. We assessed the asthma severity in diagnosed asthmatics

within the preceding year of the survey, but not a process of asthma development; thus, the time period of asthma severity was compatible with the time period of current exposure. Regarding allergic rhinitis, as it is a long-term condition, the causal relationship of allergic rhinitis and asthma severity was straightforward. On the other hand, dehumidifier use was a habit, and most probably the time period of dehumidifier use would be more than 1 year. Moreover, the straightforward causal relationship between the protective effect of dehumidifier use and asthma severity was obvious after adjusting for the socioeconomic status of asthmatics. Thus, the main conclusions would not be altered.

As the study sample was school based, we only surveyed the parents of children aged 6–15 years. One problem is that we were unable to include those without children in this survey. However, asthma has been related to delayed time to pregnancy, but not to childlessness [31]. In the current study, the reported numbers of children were not different between asthmatic and nonasthmatic parents (data not shown). Therefore, we did not expect this to distort our overall findings.

Our large cross-sectional questionnaire survey includes medication and health care use of physician-diagnosed asthmatics in urban, suburban and rural areas in southern Taiwan, which enhances the representativeness of asthma patients in a general population. However, there are several limitations in our study. First, the recall of asthma onset could have been mistaken. However, the occurrence of asthma symptoms is a crucial event, and we used the age of 12 years as a cutoff, which corresponded to memorable personal histories (elementary school periods). Even in rare cases of recall mistakes, failure to recall an early asthma history should not have affected current SABA and ICS use. Therefore, such misclassification was unlikely to bias our main conclusion that late-onset asthma was more severe than early-onset asthma. Second, in our study, the frequency categories of SABA use were designed for a general population, which was different from clinical guidelines (NAEPP and GINA). Third, a lung function test was not included as an indicator of severity in the current study. Lung function is an objective determinant of severity of airflow limitation and would be informative in determining the severity of asthma. However, in a population survey, it is extremely difficult to catch the best timing for such a test due to the high variability in lung function before, during and after asthmatic attacks. In clinical practice, the previous classification of asthma severity recommended by GINA was based on the level of symptoms, airflow limitation and lung

function variability. However, GINA reconsidered the nonstatic feature of asthma severity and the limited value of the previous classification method in predicting the treatment required for a patient. Therefore, the most updated recommendation by GINA classified asthma severity on the basis of the intensity of treatment required to achieve good asthma control instead of the level of symptoms, airflow limitation and lung function variability. This study adopted the general principle of GINA and used the intensity of treatment as the outcome.

In conclusion, late-onset asthma was more severe than early-onset asthma in adulthood. Risk factors for the severity were different between them. These findings highlight a different pathogenesis and imply a different management program for late-onset and early-onset asthma.

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Financial Disclosure and Conflicts of Interest

The authors declare that they have no conflicts of interest.

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