

Risk factors for hospital admission for asthma from childhood to young adulthood: A longitudinal population study

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Background: Predictors of hospital admissions for asthma in children and young adults in a general population are not well defined, because most studies have used selected subpopulations. **Objective:** The purpose of this investigation was to determine risk factors for single and multiple hospital admissions for asthma.

Methods: The members of a population-based, unselected birth cohort of 1037 New Zealanders answered questionnaires and underwent lung function, airway responsiveness, and allergy testing on 7 occasions to the age of 26 years.

Results: Among the 766 study members (74% of the cohort) who reported wheezing symptoms ever by the age of 26 years, 136 hospitalizations were reported by 62 individuals (8.3% of those at risk, 6.2% of the total cohort). Only 55 of these 136 admissions involved children less than 9 years of age; admissions continued to occur between the ages of 9 and 18 years (40 admissions) and at >18 years (41 admissions). Those admitted were predominantly male, had earlier ages of onset of symptoms, were more atopic, and had more airway hyperresponsiveness to methacholine than those not admitted. Frequent symptoms and low lung function were evident among the 45 study members with single admissions and even more evident among the 17 study members with multiple (2-10) admissions.

Conclusions: A surprisingly large fraction of this unselected population experienced hospitalization for asthma during the 26-year follow-up, many being admitted in later childhood, adolescence, and early adulthood. Clinical characteristics and markers of severity, including frequent respiratory symptoms,

airway hyperresponsiveness, atopy, and low lung function, identify those at high risk for hospitalization for asthma, particularly with respect to multiple admissions. (*J Allergy Clin Immunol* 2002;110:220-7.)

Key words: Asthma, hospital admission, risk factors, allergy, longitudinal population study, epidemiology

Asthma is a major cause of childhood morbidity^{1,2} and disability³ and causes considerable health care burdens in families with affected members^{3,4} and in society as a whole.⁵⁻⁷ In many countries, asthma is the most common cause for admission to a hospital during childhood.⁸ Identifying factors predicting admission might help to prevent this distressing event.^{9,10} Older children, adolescents, and young adults likewise might require hospitalization, even though the largest proportion of admissions occur in earlier childhood.

Previous studies of hospitalizations for asthma have been limited by being cross-sectional,³ hospital-based,^{11,12} register based,¹³ or based on physician practices,¹⁴ and the findings might not be applicable to a population. Clinical characteristics such as atopy, airway hyperresponsiveness (AHR), or lung function have often not been known before hospitalization, and predictive factors thus cannot be assessed and causality attributed. Several longitudinal population-based birth cohort studies of the natural history of childhood asthma have been undertaken in different countries, but to our knowledge none have addressed risk factors for hospitalization.

We have analyzed data from a longitudinal population-based birth cohort study to determine the occurrence of single and multiple hospital admissions for asthma up to the age of 26 years. The study design enabled determination of temporal variation in characteristics of asthma as predictors for severe events requiring hospitalization.

MATERIALS AND METHODS

The cohort

A birth cohort of 1037 New Zealand children born between April 1, 1972, and March 31, 1973, has been followed to the age of 26 years. Details regarding selection and attendance have been published previously.¹⁵ Briefly, study members were assessed at ages 3,

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Abbreviations used

AHR: Airway hyperresponsiveness
VC: Slow vital capacity

5, 7, 9, 11, 13, 15, 18, 21, and 26 years. Detailed respiratory studies have been conducted at each assessment from the age of 9 years. Over 26 years, 18 study members died, none as a result of asthma, leaving a living cohort of 1019 members.

The Otago Ethics Committee granted ethical approval for each phase of this longitudinal study. All study members (or parents of study members less than 18 years of age) gave informed written consent before participating in each assessment.

The questionnaires

The respiratory questionnaires, which were based on the American Thoracic Society and the International Union Against Tuberculosis and Lung Disease questionnaires, have been described in detail previously.¹⁵ Significant wheeze was defined as all reported wheezing, irrespective of what factors were considered causal, but we excluded trivial wheezing occurring only once or twice in a year and lasting less than an hour. The term *current symptoms* referred to symptoms occurring in the last 12 months before each assessment. Diagnosed asthma was recorded when this was specifically affirmed in the questionnaire.

Inasmuch as hospitalization for asthma would rarely, if ever, occur in those without preceding symptoms, study members were considered to be at risk for admission to a hospital if they reported wheezing in the period under review (regardless of the severity of symptoms).

This question was asked at each assessment: *Have you ever been in hospital because of asthma or wheezing?* From the age of 15 years, this was followed by these 2 questions: *If yes, how many times altogether?* and *How many times have you been hospitalized because of asthma or wheezing in the last 2 years?* (or 3 years or 5 years, depending on the survey interval). Absence from school was determined by the response to the following question: *Have you lost any days of school [at later ages, of work] because of asthma or wheezing in the last year?*

The smoking history was obtained through use of a self-administered, confidential questionnaire at each assessment from the age of 15 years. Tobacco smokers were defined as those who admitted smoking 1 or more cigarettes daily for at least 1 year at the age of 15 years or afterward. The socioeconomic status of each family was assessed through use of the Elley and Irving¹⁶ index on the basis of the father's occupation.

Lung function

Spirometry was performed at all assessments from the age of 9 years.¹⁷ At ages 9, 11, 13, 15 and 21 years, when methacholine challenge was also undertaken, spirometry was performed through use of a water spirometer (Godart, Bilthoven, The Netherlands), whereas at the age of 18 years and at the age of 26 years, spirometry was performed through use of a computerized spirometer and a body plethysmograph, respectively. Measurements of slow vital capacity (VC) were repeated to obtain at least 3 satisfactory and repeatable (to within 5%) measurements; these were followed by forced expiratory maneuvers to record FEV₁, again on at least 3 occasions, to obtain reproducible data.

A bronchodilator was used as part of the assessment protocol for all study members at the ages of 18 years and 26 years. At other assessments, bronchodilator inhalation was given only if there was baseline airflow obstruction of such severity that a methacholine challenge was not practical or safe. Salbutamol 5 mg/mL nebulizer

solution was administered by means of a Hudson updraft nebulizer (Hudson, Temecula, Calif; output, 0.20 ± 0.02 mL/min at an airflow of 6 L/min) during 2 minutes of tidal breathing. Spirometry was repeated 10 minutes after completion of bronchodilator inhalation. The change in FEV₁ after bronchodilator inhalation was expressed as the difference between the postbronchodilator and prebronchodilator values as a percentage of the prebronchodilator value.

Predicted values of FEV₁ and VC were calculated by sex-specific linear regression equations derived from reference study members from the cohort with no previous history of asthma ever, no history of smoking ever, and no reported wheeze within the previous year, height being used as the dependent variable. Age was not used in the equations, because the study members at each assessment were all of the same age.

Airway hyperresponsiveness

Methacholine challenge was performed through use of an abbreviated method modified from Chai et al.^{17,18} Briefly, after baseline spirometry was recorded, methacholine 0.025 mg/mL was nebulized by means of a Hudson updraft nebulizer (output 0.20 ± 0.02 mL/min) and the study member was asked to take 5 deep breaths of the aerosol. If FEV₁ had not fallen more than 20% below baseline, 5 inhalations of methacholine were given sequentially in 10-fold-increasing concentrations of 0.25, 2.5, and 25.0 mg/mL, with spirometry after each dose. The test was terminated when FEV₁ declined by more than 20% of baseline value, when the final concentration was reached, or (in a few instances) when symptoms were of concern. The provoking concentration of methacholine causing a fall in FEV₁ (PC₂₀) of exactly 20% was determined by interpolation on a log-linear plot of concentration and FEV₁. A PC₂₀ of ≤8 mg/mL was used to identify AHR. In those in whom a methacholine challenge was not safe or practical to perform, an increase in FEV₁ of ≥10% after bronchodilator inhalation was regarded as hyperresponsiveness equivalent to a methacholine PC₂₀ of ≤8 mg/mL.

Atopic status

Atopic status was assessed at the ages of 13 years and 21 years by skin prick testing for the following 11 allergens: house dust mite (*Dermatophagoides pteronyssinus*; supplied by Bencard, Brentford, Middlesex, United Kingdom), rye grass pollen, cat epithelium, dog hair, horse hair, kapok, wool, *Aspergillus fumigatus*, and alternaria, penicillium, and cladosporium molds (all supplied by Hollister-Stier Laboratories, Spokane, Wash).¹⁹ The response of a wheal at least 2 mm greater than that resulting from the negative control (diluent) was regarded as indicating atopy. Serum IgE was measured in duplicate by the Phadebas PRIST assay (Pharmacia Diagnostics, Uppsala, Sweden) at the age of 11 years and again at the age of 21 years. Blood eosinophils were measured only at the age of 21 years.

Statistical analysis

Differences in dichotomous variables and in continuously distributed variables were evaluated through use of a χ^2 test, a *t* test, and a paired *t* test. Multiple logistic regression (entry method) was used to assess the impact of sex, age of onset of symptoms, socioeconomic status of the household, total number of positive skin prick test results at the age of 13 years, presence of house dust mite allergy at the age of 13 years, presence of cat allergy at the age of 13 years, AHR at the age of 15 years, FEV₁ percent predicted at the age of 15 years, and presence of smoking ever on the outcomes. AHR at the age of 15 years was selected for our comparison to reduce the possible bias of AHR due to small airway size at younger ages.²⁰ The outcome variables were admission to a hospital ever and admission to a hospital in each of 3 age periods: before the age of 9

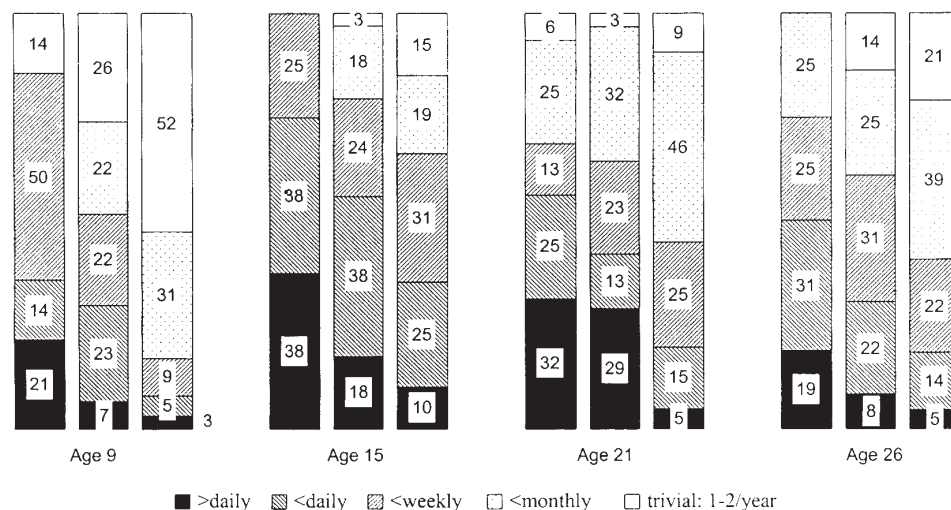


FIG 1. Prevalences (%) of different frequencies of wheezing reported at the ages of 9, 15, 21, and 26 years in study members with multiple admissions (*left columns*), study members with single admissions (*center columns*), and study members at risk but not admitted (*right columns*). For all comparisons, $P < .001$.

TABLE I. Numbers of study members at risk (with wheeze symptoms) and hospitalized for asthma or wheeze by age group

Age group	No. at risk (wheeze in period)	No. admitted to hospital in period (%)	No. with first hospitalization in period (%)	No. of hospitalizations in period
0-9 y	253	24 (9.5)	24 (9.5)	55
> 9-18 y	552	37 (6.9)	24 (4.5)	40
> 18-26 y	599	40 (6.7)	14 (2.5)	41
Birth to 26 y	766	62 (8.3)	62 (8.3)	136

years, between 9 and 18 years of age, and after the age of 18 years. Two-tailed tests were used with a 5% significance level. Statistical analyses were performed with the Statistical Package for Social Sciences (SPSS-PC 10.0.5; SPSS Inc, Chicago, Ill)

RESULTS

Study members at risk

A total of 766 study members (74%) reported wheezing symptoms ever by the age of 26 years and were therefore regarded as being at potential risk for admission to a hospital for asthma or wheeze. There was no sex difference in the proportion of study members at risk.

Admission to hospital ever

During the 26-year observation period, 62 study members (8.3% of those at risk, or 6.2% of the unselected cohort) were hospitalized for asthma on 136 occasions (Table I). Each of 45 study members had a single admission, and 17 study members had multiple admissions (range, 2-10 admissions). More males were admitted than females (11.1% vs 5.3%; $P = .003$). Males dominated admissions at each time interval (0-9 years, 11.9% vs 5.9%, $P = .16$; 9-18 years, 9.2% vs 4.6%, $P = .045$; 18-26 years, 9.4% vs 4.2%; $P = .0015$).

Study members with an admission to a hospital for asthma or wheeze were more often previously diagnosed with asthma and had an earlier age of onset of symptoms,

more allergy measured as the total number of positive skin prick test results, more cat allergy, more house dust mite allergy, higher total IgE levels at the age of 11 years and at the age of 21 years, and higher blood eosinophilia at the age of 21 years (Table II). The frequency of symptoms at each assessment was higher in those with an admission to a hospital for asthma or wheeze than in study members at risk ($P < .001$). Fig 1 shows the association between the frequency of reported wheezing in different phases in (a) those study members at risk but not admitted, (b) those with single admissions, and (c) those with multiple admissions. Hospitalized study members had lower lung function indices, more reversibility to salbutamol at the age of 18 years and at the age of 26 years, and more AHR than study members at risk (Table III). These differences were also seen when the analysis was restricted to only those reporting diagnosed asthma (not tabulated). Of 52 hospitalized study members who had had measurements of AHR before the event, 30 (58%) had shown hyperresponsiveness.

Multiple admissions

A male predominance was equally seen in readmissions and single admissions (Table IV). Study members with multiple admissions had an earlier onset of symptoms, more allergy (as measured by the total number of positive skin prick test results), and more cat allergy at the age of

TABLE II. Clinical characteristics of study members admitted to hospital for asthma or wheeze ever when compared with study members at risk but not hospitalized

	Admission to hospital for asthma or wheeze		P value
	Yes	No	
n	62	704	—
Male (%)	66%	49%	.003
Birth weight (g)	3429 ± 436	3389 ± 519	.56
Breast-feeding (≥4 wk)	59%	45%	.03
Parental smoking	64%	65%	.97
Parental history of asthma or hay fever	53%	47%	.37
Diagnosed asthma reported ever	89%	36%	<.0001
Age of onset of wheeze (y)	4.3 ± 4.5	12.0 ± 9.1	<.0001
Diagnosed asthma at age 9 y	54%	8%	<.0001
Diagnosed asthma at age 15 y	72%	14%	<.0001
Diagnosed asthma at age 21 y	71%	17%	<.0001
Eczema at age 9 y	24%	11%	.006
Hay fever at age 9 y	36%	17%	<.0001
Serum total IgE at age 11 y* (IU/mL)	451	110	<.0001
Serum total IgE at age 21 y* (IU/mL)	290	50	<.0001
Blood eosinophils at age 21 y* (10 ⁹ cells/L)	0.30	0.19	<.0001
Blood eosinophils at age 21 y (%)	4.3	2.9	<.0001
No. of positive allergy test results at age 13 y†	3.2 ± 2.2	1.0 ± 1.5	<.0001
Atopy at age 13 y (at least 1 SPT ≥2 mm)	88%	44%	<.0001
House dust mite allergy at age 13 y (≥2 mm)	80%	30%	<.0001
Cat allergy at age 13 y (≥2 mm)	52%	12%	<.0001
No. of positive allergy tests at age 21 y	5.4 ± 2.9	2.3 ± 2.7	<.0001
Atopy at age 21 y (≥1 SPT ≥2 mm)	98%	66%	<.0001
House dust mite allergy at age 21 y (≥2 mm)	96%	57%	<.0001
Cat allergy at age 21 y (≥2 mm)	67%	30%	<.0001
Heavy smoker at age 26 y‡	44%	43%	.76
Ever lost a day at school or work	64%	17%	<.0001
Total days of absence from work or school	8 ± 11	1 ± 5	<.0001
Socioeconomic status (low)	51%	62%	.11

Measurements given as means (± SDs where appropriate).

SPT, Skin prick test result.

*Geometric mean and test on logarithmic values provided.

†Response of a wheal at least 2 mm greater than that resulting from the negative control (diluent) was regarded as indicating atopy.

‡More than 10 cigarettes daily for at least 1 year.

13 years than those with single admissions. No difference was found in measures of allergy at the age of 21 years between the 2 groups. At all assessments, symptoms were more frequent in study members with multiple admissions ($P < .01$; Fig 1). A lower FEV₁ percent predicted, more AHR at the age of 9 years and at the age of 15 years, and more reversibility to salbutamol also differentiated these 2 groups (Table V). At all ages, the FEV₁/VC ratio was most impaired in the study members with multiple admissions and was intermediate in those with single admissions in comparison with study members at risk (Fig 2).

Treatment

Study members with admissions to a hospital for asthma or wheeze were overall more likely than study members at risk to have been treated with inhaled steroid ever (49% vs 10%; $P < .0001$), β -agonist (83% vs 27%; $P < .0001$), or any asthma drug (94% vs 34%; $P < .0001$). At the assessment before hospitalization, only 6 (10%) and 13 (21%) of the study members reported the use of inhaled steroid or β -agonists, respectively, whereas 13

(21%) and 31 (49%) of the study members reported the use of inhaled steroid and β -agonists, respectively, in the assessment after hospitalization.

Risk factors for admission to hospital are shown as adjusted odds ratios in Table VI. The factors independently associated with hospitalization differed during different periods. Hospitalization ever for asthma or wheeze was associated with male sex, early age of onset of symptoms, and AHR to methacholine at the age of 15 years. Hospitalization before the age of 9 years was independently associated with early age of onset of symptoms. AHR at the age of 15 years was an independent marker for hospitalization between 9 and 18 years of age. Hospitalization after the age of years of 18 was independently associated with atopy, as reflected in the total number of positive skin prick test results at the age of 13 years.

DISCUSSION

The longitudinal nature and rigorous follow-up of this epidemiologic study has enabled us to examine factors in

Asthma, rhinitis,
other respiratory
diseases

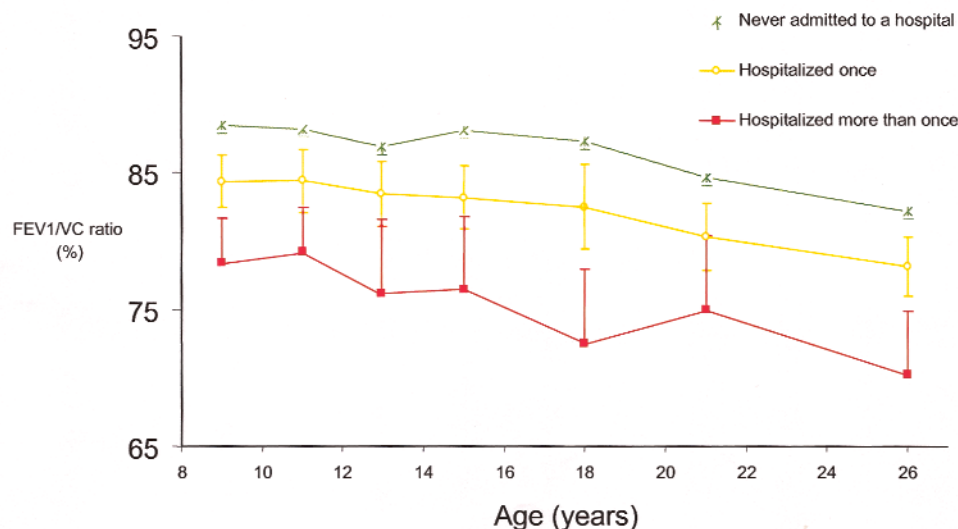


FIG 2. FEV₁/VC ratio: study members with single and multiple admissions versus study members at risk.

TABLE III. Pulmonary function characteristics of study members admitted to a hospital for asthma or wheeze at least once up to the age of 26 years compared with study members at risk but not hospitalized

	Admission to hospital for asthma or wheezing		P value
	Yes	No	
n	62	703	
FEV ₁ % predicted at age 9 y	92 ± 13	98 ± 11	<.0001
FVC % predicted at age 9 y	99 ± 11	99 ± 10	.73
FEV ₁ /VC at age 9 y (%)	83 ± 7	88 ± 7	<.0001
FEV ₁ % predicted at age 26 y	89 ± 15	97 ± 12	<.0001
FVC % predicted at age 26 y	98 ± 12	99 ± 12	.24
FEV ₁ /VC at age 26 y (%)	76 ± 9	82 ± 7	<.0001
AHR* at age 9 y (%)†	62	18	<.0001
AHR at age 15 y (%)†	53	7	<.0001
AHR at age 21 y (%)†	33	9	<.0001
Percent increase in FEV ₁ after bronchodilator at age 18 y	12 ± 13	4 ± 5	<.0001
Percent increase in FEV ₁ after bronchodilator at age 26 y	10 ± 12	5 ± 6	<.0001

Measurements given as means ± SDs.

AHR, Airway hyperresponsiveness.

*PC₂₀ ≤ 8 mg/mL or bronchodilator response ≥ 10%.

†Percent of those tested at each age.

a general population that identify those at risk of hospital admission for asthma. Hospitalizations for asthma or wheeze during the first 26 years of life occurred in 6.2% of this unselected population; they were highest in early childhood but continued to early adulthood. New Zealand has one of the highest prevalences of asthma in the world,²¹ which might in part explain the high number of study members with a hospitalization for asthma; however, living conditions do not differ fundamentally from those in other western countries, suggesting that these findings might be generalizable to other countries.

This study has complemented and extended previous research that was based on register- and hospital-based cohorts. Male sex^{22,23} and severe asthma (reflected in frequent respiratory symptoms,³ AHR,^{12,24} atopy,²⁵⁻²⁷ medication use,²⁸⁻³⁰ and low lung function¹²) have previously

been shown to identify those at high risk for hospitalization for asthma. Using the longitudinal study design, we have shown these markers to be predictors of exacerbations, and we further showed that the frequency of symptoms at each assessment was progressively higher among those with single and multiple admissions, respectively.

AHR documented before the index event was a common but not consistent finding. AHR is neither highly sensitive nor specific for asthma,^{20,31} but a closer association might have been found if the testing had been performed close to the time of hospitalization. AHR at the age of 15 years was selected for our comparison to reduce the bias of AHR associated with small airway size at younger ages,²⁰ but similar results were obtained through use of measurements of AHR at other ages.

Atopy might be a risk factor for hospitalization for 2

TABLE IV. Clinical characteristics of study members with multiple hospital admissions from birth to the age of 26 years compared with study members with a single admission for asthma or wheeze

	Admitted to hospital for asthma or wheezing		P value
	Multiple	Single	
n	17	45	
Male (%)	65%	67%	.96
Birth weight (g)	3339 ± 481	3470 ± 413	.28
Breast feeding (≥4 wk)	56%	61%	.70
Parental smoking	77%	58%	.18
Parental history of asthma or hay fever	53%	54%	.80
Diagnosed asthma reported ever	90%	89%	.98
Age of onset of wheeze (y)	2.7 ± 4.3	5.2 ± 4.9	.05
Diagnosed asthma at age 9 y	78%	44%	.01
Diagnosed asthma at age 15 y	83%	66%	.17
Diagnosed asthma at age 21 y	83%	64%	.14
Eczema at age 9 y	29%	21%	.50
Hay fever at age 9 y	29%	40%	.47
Serum total IgE at age 11 y* (IU/mL)	456	448	.96
Serum total IgE at age 21 y* (IU/mL)	364	244	.28
Blood eosinophils at age 21 y* (10 ⁹ cells/L)	0.26	0.31	.48
Blood eosinophils at age 21 y* (%)	3.1	3.9	.18
No. of positive allergy tests at age 13 y†	4.4 ± 3.2	2.6 ± 2.2	.005
Atopy at age 13 y (at least 1 SPT ≥2 mm)	88%	88%	.94
House dust mite allergy at age 13 y (≥2 mm)	69%	85%	.17
Cat allergy at age 13 y (≥2 mm)	75%	41%	.03
No. of positive allergy tests at age 21 y	6.4 ± 3.4	4.9 ± 3.1	.07
Atopy at age 21 y (at least 1 SPT ≥2 mm)	94%	100%	.32
House dust mite allergy at age 21 y (≥2 mm)	94%	97%	.58
Cat allergy at age 21 y (≥2 mm)	77%	61%	.27
Heavy smoker at age 26 y‡	61%	54%	.62
Total days of absence from school or work	13 ± 13	6 ± 9	.01
Socioeconomic status (low)	53%	49%	.76

Measurements given as means ± SDs.

SPT, Skin prick test result.

*Geometric mean and test on logarithmic values provided.

†Response of a wheal at least 2 mm greater than that resulting from the negative control (diluent) was regarded as indicating atopy.

‡More than 10 cigarettes daily from the age of 15 years for at least 1 year.

reasons: first, through allergen exposure causing exacerbations; second, by identifying a more severe and unstable disease.³² Allergy to indoor allergens such as house dust mites, cat dander, and cockroach might be particularly important because of persistent and long-term exposure.^{25,27,33} Atopic asthma increases with age during childhood,²⁰ so the risk for hospitalization for asthma might be increased both by an increased likelihood of exacerbations and by development of more severe disease because of more frequent exposure to a greater number of relevant allergens.^{27,32}

A greater degree of airflow obstruction, as measured by the FEV₁/VC ratio, was present in study members with multiple admissions than in study members at risk from the first time lung function was measured at the age of 9 years through the entire survey period to the age of 26 years. Similarly, greater reversibility was found in the response to bronchodilator inhalation at the age of 18 years and at the age of 26 years. We confirmed the findings of Li et al,¹² who reported that among adults with asthma selected from general practices, those hospitalized had greater impair-

ment of lung function than those not hospitalized.

Treatment was infrequent among study members hospitalized for asthma or wheeze both before and after hospitalization. Undertreatment relative to disease severity has frequently been reported in other populations hospitalized for asthma.³⁰ We cannot assess whether this undertreatment was due to noncompliance, to denial by the study member,^{28,30} or to insufficient treatment by the doctor.³⁴ Blais et al¹³ emphasized the importance of adequate treatment by showing that regular treatment with inhaled corticosteroids initiated after the recognition of asthma could reduce the risk of hospital admission for asthma in comparison with treatment with theophylline.¹³

The phenotype of asthma changes somewhat from infancy to early adulthood in regard to symptom pattern, IgE levels, and degree of atopy, which might explain the change in markers of risk in different periods.²⁰ An early onset of symptoms was associated with admission and readmission for asthma or wheeze in younger children, but this predictive factor weakened with age. This is in accordance with findings that subjects with early persis-

Asthma, rhinitis,
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diseases

TABLE V. Pulmonary function characteristics of study members with multiple hospital admissions up to the age of 26 years compared with study members with only a single hospital admission for asthma or wheeze

	Admitted to hospital for asthma or wheezing		P value
	Multiple	Single	
n	17	45	
FEV ₁ % predicted at age 9 y	86 ± 11	94 ± 13	.04
FVC % predicted at age 9 y	99 ± 12	99 ± 10	.93
FEV ₁ /VC at age 9 y (%)	78 ± 7	84 ± 6	.003
FEV ₁ % predicted at age 26 y	79 ± 18	93 ± 13	.001
FVC % predicted at age 26 y	94 ± 14	100 ± 11	.09
FEV ₁ /VC at age 26 y (%)	70 ± 10	78 ± 7	.001
AHR at age 9 y* (%)†	82	51	.03
AHR at age 15 y (%)†	71	39	.04
AHR at age 21 y (%)†	40	29	.46
Percent increase in FEV ₁ after bronchodilator at age 18 y	20 ± 17	9 ± 9	.002
Percent increase in FEV ₁ after bronchodilator at age 26 y	16 ± 17	7 ± 7	.006

Measurements given as mean ± SD.

AHR, Airway hyperresponsiveness.

*PC₂₀ ≤ 8 mg/mL or bronchodilator response ≥ 10%.

†Percent of those tested at each age.

TABLE VI. Adjusted associations of risk factors (odds ratios) and their 95% confidence intervals (95%CI) for outcome variables: admission to a hospital ever, and hospitalization in each of three age periods: before the age of 9 years, between 9-18 years, and after the age of 18 years, for asthma or wheeze

	Hospitalization			
	Ever	Before age 9 y	Between age 9 y and age 18 y	Between age 18 y and age 26 y
Sex: male*				
OR	2.1 (1.0-5.1)	3.3 (0.8-14.1)	3.3 (0.8-13.7)	0.7 (0.2-2.4)
P	.05	.10	.09	.60
Onset of symptoms of asthma (per 5 y earlier)*				
OR	1.8 (1.2-2.9)	13.5 (1.2-57.3)	0.8 (0.2-3.0)	2.2 (0.7-7.4)
P	.006	.04	.60	.20
AHR at age 15 y*†				
OR	4.0 (1.6-10.2)	3.5 (0.9-14.2)	9.0 (2.1-40.0)	0.9 (0.4-8.8)
P	.004	.08	.004	.42
No. of positive tests at age 13 y (per positive test result)*				
OR	1.1 (0.8-1.4)	1.1 (0.8-1.6)	1.2 (0.8-1.7)	1.6 (1.1-2.3)
P	.53	.53	.57	.01
Cat allergy* (≥2 mm)				
OR	1.9 (0.6-5.9)	2.8 (0.5-16.1)	1.2 (0.2-7.0)	0.6 (0.1-2.6)
P	.29	.24	.81	.41
House dust mite allergy* (≥2 mm)				
OR	2.3 (0.8-6.6)	0.9 (0.2-4.6)	1.7 (0.3-13.7)	1.1 (0.3-4.9)
P	.13	.94	.50	.88
FEV ₁ percent predicted at age 9 y (per 10% decrease)*				
OR	1.2 (0.9-1.7)	1.2 (0.8-1.8)	1.2 (0.8-1.9)	0.8 (0.5-1.3)
P	.15	.57	.38	.47

AHR, Airway hyperresponsiveness.

*Adjusted for all factors tabulated, socioeconomic status, and heavy smoking.

†PC₂₀ ≤ 8 mg/mL or bronchodilator response ≥10%.

tent asthma have a poorer clinical outcome³⁵ but that many subjects outgrow their symptoms.³⁶ As this predictive factor weakened, the impact of atopy on the risk of admission became more evident (Table VI).

In our study, socioeconomic status, in crude or in adjusted associations, was not associated with hospitalizations; this is in contrast to the findings of others.^{14,37} This

was also evident if socioeconomic status was analyzed in 6 categories according to the Elley and Irving index¹⁶ (not tabulated). Health care cost and availability and socioeconomic status might influence hospitalization.³⁷ Eisner et al¹⁴ found a less strong association between lower household income and hospitalizations when asthma severity was included in the model and suggested that greater asth-

ma severity might partly mediate this association. The free access and good availability of health care in New Zealand is likely to lessen the strength of association between income and admission to a hospital for asthma.

In conclusion, in this population-based study, more than 6% of those in an unselected population experienced a hospitalization for asthma or wheeze during the first 26 years of life. These serious events were not restricted to early childhood but continued into young adulthood. Markers of severity, such as frequent respiratory symptoms, AHR, atopy, and low lung function, were more common among those hospitalized. Our longitudinal study design has shown that these markers are present before hospitalization and are predictors of those at high risk for hospitalization for asthma, particularly with respect to multiple admissions.

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