ARTICLE

Persistence and Remission in Childhood Asthma

A Population-Based Asthma Birth Cohort Study

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Objectives: To examine and predict the persistence of childhood asthma.

Design: Longitudinal population-based cohort study.

Setting: Ontario, Canada.

Participants: Children born in 1994 and diagnosed with asthma before age 6 years were followed up until age 11 years. Diagnosis of asthma was defined as 1 asthma hospitalization or 2 asthma physician claims within 3 years prior to age 6 years.

Main Exposure: Intensity of health services use within 1 year postdiagnosis.

Main Outcome Measures: Those who continued to have asthma events (hospitalization and/or physician visit) between ages 6 and 11 years were considered to have "persistent asthma," while others were in "remission." Cumulative rates of health services use for asthma during follow-up were calculated. Logistic regression analysis was used to estimate risks of persistent asthma.

Results: The study included 34 216 children diagnosed with asthma before age 6 years. More than half (54.4%) experienced a second asthma health care encounter within 1 year after diagnosis. By age 12 years, nearly half (48.6%) were in remission. Children with asthma hospitalization during the first year postdiagnosis had a 3-fold risk of persistent asthma by age 12 years (95% confidence interval, 2.69-3.39; $P<.001$). Those with at least 4 physician visits also had a 2.6-fold risk of persistent asthma during follow-up (95% confidence interval, 2.34-2.81; $P<.001$).

Conclusion: The concentration of health services use within 1 year following the initial diagnosis of childhood asthma points to the need for attentive follow-up and ongoing management and education strategies in the early years.

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ASTHMA IS THE MOST COMmon chronic disease and the most common reason for hospitalization in children.[1-5] Childhood asthma is a major global health problem that exerts a substantial burden not only on the child but also on the family, health care systems, and society as a whole.[4,5]

Several longitudinal studies suggest that the natural history of asthma is often characterized by periods of remission and relapse. The Tucson Children's Respiratory Study (TCRS)[6] showed that 58% of children with asthma diagnosed before puberty reported the presence of wheezing after the onset of puberty. The TCRS also demonstrated that the patterns of wheezing and levels of lung function established by age 6 years did not change significantly by age 16 years in children who started having asthmalike symptoms during the preschool years.[7] Taylor et al[8] found that 35% of children with asthma in a New Zealand birth cohort who were in remission at 18 years of age relapsed by age 26 years. Strachan et al[9] followed up a British cohort born in 1958 and found that 16% of those who wheezed before age 7 years were free of attacks between the ages of 16 and 23 years but later reported wheezing at the age of 33 years. Similarly, Robertson[10] in Australia found that children with persistent and severe asthma continued to have asthma symptoms into adulthood, with 79% experiencing recent asthma symptoms at the age of 42 years. Vonk et al[11] reported that 52% of a Netherland cohort of children with allergic asthma were in remission by ages 32 to 42 years and 22% of them were in complete remission with no asthma symptoms, no steroid use, normal lung function, and no bronchial hyperresponsiveness.

The pattern of asthma during childhood seems to be a strong predictor of its long-term course and outcomes. Chil-

dren with episodic asthma generally have better outcomes in adulthood, with either complete resolution or only mild symptoms.[10] Alternatively, those with persistent asthma in childhood are more likely to have their asthma persist into adult years, with modest impairment of lung function.[10] The ability to predict persistent asthma in early childhood would help clinicians identify children in need of ongoing asthma management, education, and follow-up.

Longitudinal cohort studies of childhood asthma are few. Most previous studies focused on local populations, differed in methods, and used different definitions of asthma diagnosis and remission. To further understand the natural history of asthma, the current study used provincial population-based data to follow up young children with asthma from birth until early adolescence and investigated the occurrence of persistence and remission of asthma in childhood. We closely examined patterns of health service use as a predictor of asthma persistence because children with significant morbidity for asthma in the past are at increased risk for future morbidities.[12-17]

METHODS

SOURCES OF DATA

This study used 3 Ontario health care administrative databases: (1) the hospital discharge abstract database, which is prepared by the Canadian Institute for Health Information (CIHI) and includes the records for all provincial hospitalizations; (2) the Ontario Health Insurance Plan (OHIP) records database, which provides health services billing data and contains the fee-for-service codes billed by all physicians in the province, including family physicians, pediatricians, specialists, and physicians working in emergency departments; and (3) the Registered Persons Database, which contains demographics and mortality data. Variables used from the CIHI database included the unique identifier, patient residence code, admission and discharge dates, and up to 16 diagnosis codes. Variables used from the OHIP database included the unique identifier, service date, diagnosis code, and fee code. Emergency department visits were identified based on the "H-" suffix recorded in the OHIP fee codes. Variables from the Registered Persons Database included the unique identifier, sex, birth date and, if applicable, date of death. The unique identifier included in each database is a reproducible scrambled identifier, which permits the linkage of an individual's records across databases and time while preserving patient confidentiality. Ethics approval for this study was received from the Research Ethics Boards of The Hospital for Sick Children and the Institute for Clinical Evaluative Sciences.

STUDY COHORT AND DEFINITION OF ASTHMA

This study included all Ontario babies born between January 1, 1994, and December 31, 1994, and diagnosed with asthma before their sixth birthday. A diagnosis of asthma in early childhood was determined if a child had at least 1 asthma hospitalization or 2 asthma physician claims within a 3-year period prior to age 6 years.[18] This was based on an algorithm for children that we previously established to have 90% sensitivity and 70% specificity compared with a clinical gold standard.[18] The date of asthma diagnosis was defined as the discharge date of the earliest asthma hospitalization or the service date of the last of 2 asthma physician visits used to establish the diagnosis. The *International Classification of Diseases, Ninth Revision (ICD-9)* code 493 was used to identify asthma claims between April 1, 1994, and March 31, 2002, while *ICD-10* codes J45 and J46 were used for subsequent years. Since there could be multiple physician billings per patient per physician visit, for the purposes of this study only 1 claim per physician per day was used.

DEFINITION OF FOLLOW-UP ASTHMA STATUS

The study cohort was followed up for 6 years from ages 6 to 11 years (up until their 12th birthday). During the follow-up period, any additional asthma hospitalizations or physician visits attributable to asthma were noted. At the end of age 11 years, those who had additional asthma encounters during follow-up were considered to have "persistent asthma," while those who did not continue to have asthma claims were considered to be in "remission."

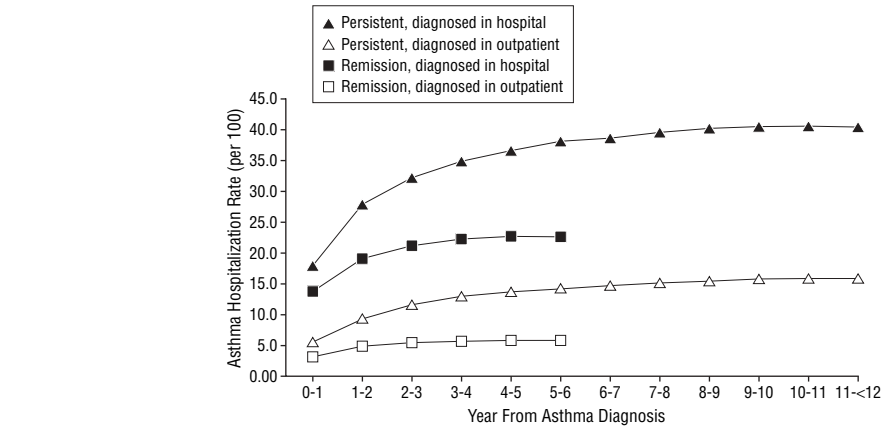
COVARIATES

Covariates included were age at asthma diagnosis, sex, birth weight, health services use in the first year postdiagnosis, history of atopic conditions, source of initial diagnosis (hospitalization vs physician visit), urban vs rural living, and socioeconomic status. Birth weight and sex were obtained from hospital birth records. The intensity of health services use for asthma in the first year postdiagnosis was used as a proxy measure for asthma severity[12] and classified into 6 mutually exclusive categories: at least 1 hospitalization, at least 4 physician visits, 3 physician visits, 2 physician visits, 1 physician visit, and no health care encounter. The history of atopic conditions was defined as having any hospitalizations or physician visits for hay fever (*ICD-9* code 477)[19,20] or atopic dermatitis/eczema (*ICD-9* codes 691-693)[21,22] prior to age 6 years. We did not further control for other childhood comorbidities because little is known about their associations with the persistence of childhood asthma. While children with bronchopulmonary dysplasia may have long-term pulmonary sequelae, the condition is rare[23] and highly correlated with low birth weight, which we were able to measure.

Rurality and socioeconomic status were obtained by linking the study cohort to Canadian census 1996 data using patients' postal code recorded at the time of asthma diagnosis. Rurality was defined based on the "rural and small town" definition used by Statistics Canada.[24] All areas and small towns with a community size less than 10 000 persons were classified as "rural." Socioeconomic status was measured by the Neighborhood Income Quintile at the enumeration area level (smallest geographical unit in census 1996).[25] Enumeration areas were ranked within the same census metropolitan area or census agglomerations into 5 quintiles from quintile 1 (poorest) to quintile 5 (richest) according to the household size–adjusted family income in the neighborhood.

ANALYSES

The χ^2 test was used to compare follow-up asthma status by covariates. The number of hospitalizations and physician visits in each year was computed longitudinally in the "persistent" and "remission" groups stratified by source of initial diagnosis. The cumulative asthma hospitalization rate and physician visit rate were obtained using Kaplan-Meier estimates, which adjust for the different lengths of observation from time of diagnosis to end of follow-up. As with asthma diagnosis, when there were multiple physician billings per patient per physician visit, only 1 claim per physician per day was used. All physician claims with a service date within the admission



Hospitalization Rates												
Persistent, diagnosed in hospital	17.5	27.6	31.8	34.7	36.3	37.8	38.3	39.3	39.9	40.2	40.3	40.3
Persistent, diagnosed in outpatient	5.1	9.1	11.3	12.7	13.5	14.0	14.5	14.9	15.3	15.5	15.7	15.8
Persistent, overall	6.3	11.0	13.4	14.9	15.8	16.5	16.9	17.4	17.8	18.0	18.2	18.3
Remission, diagnosed in hospital	13.7	18.8	20.8	22.1	22.5	22.6	NA	NA	NA	NA	NA	NA
Remission, diagnosed in outpatient	3.0	4.6	5.2	5.4	5.6	5.7	NA	NA	NA	NA	NA	NA
Remission, overall	3.9	6.0	6.7	7.1	7.2	7.3	NA	NA	NA	NA	NA	NA
Overall	5.2	8.5	10.1	11.1	11.6	12.0	12.3	12.5	12.7	12.8	12.9	12.9

Figure 1. Cumulative asthma hospitalization rates in children with asthma. Hospitalization rates were calculated based on the Kaplan-Meier survival estimates. NA indicates not applicable.

and discharge dates of a CIHI record were excluded. A logistic regression model was used to estimate the risks of persistent asthma while adjusting for other covariates. Risk estimates were presented with 95% confidence intervals. Since a 1-year follow-up window was needed to identify health services use postdiagnosis, only those diagnosed with asthma prior to age 5 years were included in the logistic regression analysis. The interaction between age at diagnosis and the intensity of health services use was also included in the logistic regression model. Both forward and backward selection methods were used to determine the most statistically significant multivariable model measured by the Hosmer-Lemeshow test. The final models include only covariates that were statistically significant at $P < .05$. The SAS statistical package (version 9.0; SAS Institute Inc, Cary, North Carolina) was used for all analyses.

RESULTS

STUDY POPULATION

Of the 123 707 babies born in 1994 in Ontario, 34 216 (27.7%) were diagnosed with asthma in early childhood (prior to age 6 years). The majority were diagnosed during a physician's visit; less than 10% were diagnosed during a hospital admission. During the 6-year follow-up period, about half (51.4%) of the study population experienced another asthma episode (ie, had persistent asthma), with 18.4% seeking acute health care (hospitalization and/or emergency department visit) for asthma.

HEALTH SERVICES USE BY FOLLOW-UP ASTHMA STATUS

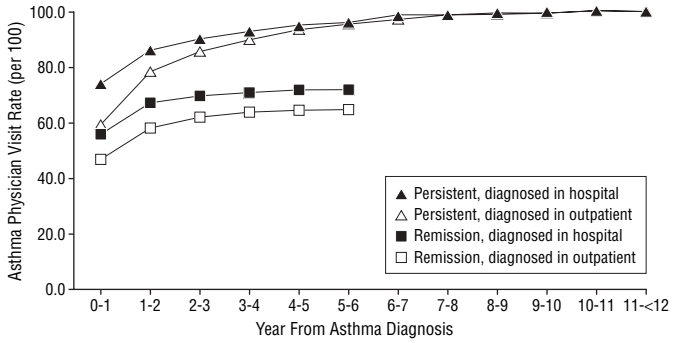
Figure 1 and **Figure 2** show the accumulative rates of health services use stratified by follow-up asthma status (persistent asthma vs remission) and source of initial diagnosis. More than 1 of 9 children (11.0%) with persistent asthma and almost 1 of 16 children (6.0%) in remission had a second asthma hospitalization within 2 years of their asthma diagnosis, representing almost a 2-fold difference ($P < .001$). This difference remained statistically significant when stratified by whether the diagnosis was made in a hospital admission vs an outpatient setting (Figure 1). Children with asthma diagnosed during a hospital admission had a significantly higher rate of asthma hospitalization during the follow-up period ($P < .001$).

Sixty percent of children with persistent asthma had a second asthma physician visit 1 year after their diagnosis, while less than half (46.9%) of those in the remission group did so ($P < .001$). By the third year postdiagnosis, 85.7% of children with persistent asthma had experienced a second physician visit for asthma. Overall, 83.8% of children with asthma had a second physician visit for asthma before they turned age 12 years (Figure 2).

Overall, more than half (54.4%; $P < .001$) of children diagnosed with asthma in early childhood experienced a second asthma episode (either hospitalization or physician visit) within a year of diagnosis, while 74.7% did so within 3 years after diagnosis. Excluding children diagnosed before age 2 years did not change the observed patterns of health service use after diagnosis.

FOLLOW-UP ASTHMA STATUS BY COVARIATES

Table 1 shows the follow-up asthma status in the study population stratified by covariates. Children with asthma diagnosed between 2 to 5 years of age were more likely to have persistent asthma by age 12 years compared with those diagnosed before age 2 years (57.5% vs 45.4%;



Physician Visit Rates												
Persistent, diagnosed in hospital	72.5	85.4	89.5	92.5	94.3	95.7	97.6	98.3	98.8	99.3	99.7	100.0
Persistent, diagnosed in outpatient	58.6	77.7	85.3	89.5	92.7	95.0	96.9	98.1	99.1	99.6	99.9	100.0
Persistent, overall	60.0	78.5	85.7	89.8	92.9	95.1	97.0	98.1	99.0	99.6	99.9	100.0
Remission, diagnosed in hospital	55.4	66.9	69.2	70.6	71.4	71.8	NA	NA	NA	NA	NA	NA
Remission, diagnosed in outpatient	46.0	57.8	61.7	63.5	64.3	64.5	NA	NA	NA	NA	NA	NA
Remission, overall	46.9	58.7	62.5	64.1	65.0	65.2	NA	NA	NA	NA	NA	NA
Overall	53.6	68.9	74.4	77.4	79.3	80.6	81.6	82.2	82.8	83.3	83.6	83.8

Figure 2. Cumulative asthma physician visit rates in children with asthma. Physician visit rates were calculated based on the Kaplan-Meier survival estimates. NA indicates not applicable.

$P<.001$). Compared with girls, boys were more likely to have persistent asthma during follow-up (52.9% vs 49.1%; $P<.001$).

Almost 1 of 4 children (23.5%) with asthma diagnosed prior to age 6 years also had hay fever or atopic dermatitis. Those with atopic conditions were more likely to have persistent asthma by age 12 years compared with those without (62.8% vs 47.9%; $P<.001$).

Children living in urban areas had a higher risk of persistent asthma than those living in rural areas (52.1% vs 45.8%; $P<.001$), whereas socioeconomic status was not statistically associated with asthma persistence.

ADJUSTED RISK ESTIMATES OF PERSISTENT ASTHMA BY LOGISTIC REGRESSION

Table 2 shows results from the multivariable logistic regression analysis. The predictor variable of interest was the intensity of health services use during the first year postdiagnosis while the asthma status at the end of age 11 years was the outcome variable in the regression model. We examined the interaction between age at diagnosis and intensity of health services use. It was significant and therefore results of stratified analyses were presented.

To observe health services use within 1 year postdiagnosis, only children diagnosed before age 5 years (n=28 418) were included in the logistic regression analysis. After adjusting for significant covariates, the estimated risk of having persistent asthma was 3-fold higher in children with at least 1 asthma hospitalization compared with those without any health care encounter for asthma during the first year postdiagnosis (odds ratio, 3.0; 95% confidence interval, 2.69-3.39; $P<.001$). Similarly, those with at least 4 physician visits also had a significantly higher risk of persistent asthma during follow-up (odds ratio, 2.6; 95% confidence interval, 2.34-2.81; $P<.001$). Similar results were obtained when stratified by age at diagnosis.

COMMENT

In a longitudinal cohort of children born in 1994 in Ontario, diagnosed with asthma prior to age 6 years, and followed up until their 12th birthday, 51.4% were found to have persistence of their asthma. Of those with persistent asthma, about one-fifth (18.4%) sought acute health care at hospitals or emergency departments during follow-up. Compared with those in asthma remission, children with persistent asthma were more likely to be diagnosed at an older age, be male, live in urban areas, have atopic conditions, and use more health care resources within 1 year after diagnosis.

The rates of persistence, remission, and relapse of asthma vary in the literature. This variation is likely attributed to diverse study designs, varying follow-up periods, and different study populations (**Table 3**). Similar to the current study, other studies have shown significant remission rates overall. The Melbourne Epidemiological Study of Childhood Asthma[10] is the longest and most comprehensive longitudinal study of childhood asthma. Children between the ages of 7 and 10 years were recruited and followed up every 7 years until the age of 42 years. At the last follow-up, 85% of the control group, 60% of those with episodic asthma, and 21% of those with persistent or severe asthma at recruitment had been free of wheezing over the previous 3 years. It suggested that there is a favorable outcome for most children with asthma as they grow toward midadult years.

The TCRS[29,30] is similar to the current study in terms of age of enrollment and follow-up period; it followed up children from birth (or soon after) up to the age of 6 years. Among children who wheezed before age 3 years, 59% had stopped wheezing by 6 years of age. This agrees with our study in that almost half (48.6%) of our asthma birth cohort was in remission by the time they turned

12 years old. A similar remission rate (50%) was also reported by Strachan et al.[9]

Vonk et al[11] defined complete or clinical remission of asthma based on the absence or presence of symptoms, medication, normal lung function, and bronchial hyperresponsiveness. They reported that between the ages of 32 and 42 years, 22% of the group was in complete remission and a further 30% was in clinical remission. This means a total of 52% was free of asthma symptoms and not using an inhaled corticosteroid.

The difference of disease pattern between sexes was also reported in many other studies. Robertson[10] showed that girls appeared to be at higher risk for continuing wheeze in adult life. Kjellman and Gustafsson,[26] as well as Sears et al,[28] reported that decreased severity was more prevalent among males than females at the last follow-up. This was also the case for Halász and Cserhati,[27] who found that males had a better chance of recovery from bronchial asthma in childhood. In contrast, the current study using health services data found that boys were more likely to have persistent asthma by age 12 years. This discrepancy is probably because of the differences in age of enrollment and length of follow-up compared with previous studies. Following our study cohort forward into adolescence will provide more in-depth understanding of the role of sex on the persistence of childhood asthma.

The association between atopic conditions and hospital resources use[19,31] or asthma persistence has been previously documented.[8,28,32] Our results also showed that having a history of hay fever or atopic dermatitis before age 6 years was associated with asthma persistence at age 12 years. This risk was more pronounced in children diagnosed with asthma before age 2 years.

Our study examined some unique aspects of childhood asthma that to our knowledge have not been studied before. The time from diagnosis to the next asthma care encounter indicated that the initial few years following asthma diagnosis were crucial. For both physician visit and hospitalization, the number of children having had a second asthma encounter peaked at 3 years after diagnosis and then stabilized. Overall, 75% had a second asthma episode (either physician visit or hospitalization) within 3 years after diagnosis. This suggests that it takes approximately 3 years to control and stabilize asthma episodes. This period may be an important marker for future studies. The concentration of asthma episodes immediately following diagnosis points to the need for attentive follow-up and ongoing management and education strategies in the early years. Other studies suggest that children who present with wheeze at an early age may experience a different clinical course compared with those who continue to wheeze at later ages.[29] However, our subgroup sensitivity analysis (by excluding those diagnosed with asthma prior to age 2 years) did not show a different pattern of health services use over time.

Our logistic regression results showed that the intensity of health services use for asthma in the first year postdiagnosis was significantly associated with the risk of persistent asthma in early adolescence. The dose-response relationship remained significant regardless of age at asthma diagnosis. Frequent use of health services following onset of asthma may serve as a marker of asthma persistence.

Table 1. Follow-up Asthma Status by Risk Factors

Risk Factor	Follow-up Status of Asthma, No. (%)[a]		*P* Value
	Persistence	Remission	
Age at diagnosis, y			
0-1	7816 (45.4)	9397 (54.6)	<.001
2-5	9774 (57.5)	7229 (42.5)	
Sex			
F	6676 (49.1)	6917 (50.9)	<.001
M	10 914 (52.9)	9709 (47.1)	
Health services use in first year postdiagnosis[b]			
At least 1 hospitalization	1557 (64.5)	858 (35.5)	<.001
At least 4 physician visits	3279 (64.3)	1824 (35.7)	
3 Physician visits	1518 (58.7)	1066 (41.3)	
2 Physician visits	2118 (54.2)	1788 (45.8)	
1 Physician visit	2990 (47.2)	3349 (52.8)	
No encounter	4143 (38.4)	6657 (61.6)	
Atopic conditions prior to age 6 y			
Had hay fever/atopic dermatitis	5041 (62.8)	2990 (37.2)	<.001
None	12 549 (47.9)	13 636 (52.1)	
Rurality			
Urban	15 837 (52.1)	14 535 (47.9)	<.001
Rural	1743 (45.8)	2065 (54.2)	
Birth weight, mean±SD, g	3335.8±631.7	3350.2±628.4	.04
Source of initial diagnosis			
CIHI (hospitalization)	1797 (52.7)	1610 (47.3)	.10
OHIP (outpatient)	15 793 (51.3)	15 016 (48.7)	
Neighborhood income quintile			
1-4	14 907 (51.7)	13 900 (48.3)	.05
5 (highest)	2574 (50.3)	2548 (49.7)	
Total	17 590 (51.4)	16 626 (48.6)	

Abbreviations: CIHI, Canadian Institute for Health Information; OHIP, Ontario Health Insurance Plan.
[a] All percentages are adjusted for missing values.
[b] Only children diagnosed at ages 0 to 4 years were included to observe health services use within 1 year postdiagnosis.

Another major advantage of this study, like the ones conducted by Sears et al[28] and Taylor et al,[8] was that it used a population-based birth cohort from a universal health care coverage system. Such a design includes children from the complete socio-ethno-demographic range and thus virtually eliminates sampling bias. Therefore, findings of this study should reflect a more comprehensive and "real" picture of the natural history of asthma in childhood.

There are some limitations of this study. Apart from the usual limitations inherent in analyzing and interpreting administrative data,[33] there are specific interpretive cautions required when examining the magnitude of the burden of asthma reported from this cohort. First, although the case verification study that was conducted to validate the use of administrative data diagnosis codes for identifying children with asthma[18] was shown to have good sensitivity and specificity for a specialist's clinical diagnosis of asthma, some disease misclassification will occur. Random disease misclassification is expected to

Table 2. Adjusted Risks of Persistent Asthma From Logistic Regression Models[a]

Risk Factor	Diagnosed at Ages 0-1 y (n=16 051)		Diagnosed at Ages 2-4 y (n=12 367)		Overall (n=28 418)	
	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Age at diagnosis, y						
2-4					1.5 (1.35-1.60)	<.001
0-1					1 [Reference]	
Sex						
M	1.2 (1.12-1.28)	<.001	1.2 (1.12-1.30)	<.001	1.2 (1.14-1.26)	<.001
F	1 [Reference]		1 [Reference]		1 [Reference]	
Health services use in first year postdiagnosis						
At least 1 hospitalization	3.0 (2.70-3.40)	<.001	4.3 (3.41-5.33)	<.001	3.0 (2.69-3.39)	<.001
At least 4 physician visits	2.6 (2.33-2.81)	<.001	4.6 (4.02-5.31)	<.001	2.6 (2.34-2.81)	<.001
3 Physician visits	2.0 (1.77-2.25)	<.001	3.0 (2.55-3.44)	<.001	2.0 (1.76-2.25)	<.001
2 Physician visits	1.7 (1.49-1.86)	<.001	2.4 (2.12-2.69)	<.001	1.7 (1.49-1.85)	<.001
1 Physician visit	1.3 (1.18-1.43)	<.001	1.6 (1.44-1.74)	<.001	1.3 (1.18-1.43)	<.001
No encounter	1 [Reference]		1 [Reference]		1 [Reference]	
Atopic conditions prior to age 6 y						
Had hay fever/atopic dermatitis	2.0 (1.81-2.12)	<.001	1.5 (1.39-1.65)	<.001	1.7 (1.64-1.84)	<.001
None	1 [Reference]		1 [Reference]		1 [Reference]	
Rurality						
Urban	1.3 (1.20-1.47)	<.001	1.1 (1.00-1.28)	.049	1.2 (1.15-1.35)	<.001
Rural	1 [Reference]		1 [Reference]		1 [Reference]	
Birth weight, per 500 g increase	0.97 (0.94-0.99)	.006			0.98 (0.96-1.00)	.01
Source of initial diagnosis						
CIHI (hospitalization)			1.2 (1.00-1.35)	.04	1.0 (0.94-1.10)	.68
OHIP (outpatient)			1 [Reference]		1 [Reference]	
Interaction between age at diagnosis (diagnosed at ages 2-4 y) and health services use[b]						
At least 1 hospitalization					1.5 (1.14-1.87)	.003
At least 4 physician visits					1.8 (1.52-2.12)	<.001
3 Physician visits					1.5 (1.23-1.81)	.001
2 Physician visits					1.4 (1.23-1.69)	<.001
1 Physician visit					1.2 (1.07-1.39)	.004

Abbreviations: CI, confidence interval; CIHI, Canadian Institute for Health Information; OHIP, Ontario Health Insurance Plan; OR, odds ratio.

[a] Only children diagnosed at ages 0 to 4 years were included to observe health services use within 1 year postdiagnosis. Only patients with complete data on all covariates were included. Model significance was measured by the Hosmer-Lemeshow test (ages 0-1 year: $\chi^2_8=3.1$; $P=.92$; ages 2-4 years: $\chi^2_7=10.6$; $P=.16$; overall: $\chi^2_8=10.3$; $P=.24$).

[b] Diagnosed at ages 0 to 1 year and no encounter are the references for the interaction term.

Table 3. Comparison of Findings With Previous Studies

Source	Study Location	No. of Subjects With Asthma/ Wheezing	Age, y		Rate of Remission, %	Remission Definition
			Diagnosis	Follow-up		
Strachan,[9] 1996	United Kingdom	880	< 7	7	50	No attacks of asthma or wheezy bronchitis in the previous year
Kjellman and Gustafsson,[26] 2000	Sweden	55	4-14	25-35	16	Free of symptoms and medication over the last year
Halász and Cserhati,[27] 2002	Hungary	145	< 18	≥ 28	43	Symptom free (no frequent cough, dyspnea, or asthma attacks and good quality of life)
Vonk et al,[11] 2004	The Netherlands	119	5-14	32-42	52	Absence of wheeze and asthma attacks and no use of inhaled corticosteroids
Robertson,[10] 2002	Australia	317	< 7	42	40	No wheeze in past 3 years
Sears et al,[28] 2003	New Zealand	445	< 26	26	21	Absence of wheezing that had been reported at ≥ 2 successive prior assessments
Taylor et al,[8] 2005	New Zealand	176	< 15	18	39	Absence of reported wheezing that had been current at ≥ 2 prior assessments
Martinez et al,[29] 1995	United States	277	0-2	6	59	Had not wheezed during previous year
Current study	Canada	34 216	0-5	11	49	No hospitalization or physician visit for asthma during 6-y follow-up

result in a bias toward the null hypothesis (a type II error), which can be overcome with large sample sizes. Fortunately, our population-based administrative databases have large enough sample sizes to minimize the effect of random misclassification error. Since one major component of asthma management is medication treatment, incorporation of such data into the algorithm may strengthen the diagnosis or definition of asthma. While we currently do not have a population-based database in Ontario that captures the use of prescribed medications in children, the sensitivity and specificity of our asthma definition were similar to that reported by Kozyrskyj et al,[34] which incorporated prescription data for asthma.

Second, our definitions of asthma persistence and remission were based on health care encounters rather than clinical parameters (eg, asthma symptoms and lung function), which are not available in health administrative databases. Therefore, clinical or subclinical active asthma cases might have been misclassified into the remission group or not identified at all.

Finally, there is potential for misclassification of young children having asthma because a large percentage of the infants who wheeze may have transient conditions that are not asthma and do not have increased risks of asthma later in life.[29] In our current study, the persistence rate would be slightly higher (57.5% vs 45.4%) if children diagnosed before age 2 years were excluded.

CONCLUSIONS

This study used a population-based asthma birth cohort to examine the natural history of asthma in childhood. Our results showed that almost half of the children diagnosed with asthma before age 6 years appeared to be in remission by the end of age 11 years. However, 1 of 2 children continued to live with persistent asthma. Those with persistent asthma were heavy users of health services and should be followed up further regarding treatment, management, and control. The second asthma health care encounter (hospitalizations or physician visits), after initial diagnosis, often occurred within 1 year. This concentration of health services use immediately following diagnosis points to the need for attentive follow-up and ongoing management and education strategies in the early years.

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Announcement

Submissions. The Editors welcome contributions to Picture of the Month. Submissions should describe common problems presenting uncommonly, rather than total zebras. Cases should be of interest to practicing pediatricians, highlighting problems that they are likely to at least occasionally encounter in the office or hospital setting. High-quality clinical images (in either 35-mm slide or electronic format) along with parent or patient permission to use these images must accompany the submission. The entire discussion should comprise no more than 750 words. Articles and photographs accepted for publication will bear the contributor's name. There is no charge for reproduction and printing of color illustrations. For details regarding electronic submission, please see: http://archpedi.ama-assn.org.