Changing prevalence of allergic rhinitis and asthma

R Michael Sly, MD

Objective: This review will enable the reader to discuss prevalence, risk factors, and prognosis of allergic rhinitis and asthma.

Data sources: MEDLINE (PubMed) search using the terms allergic rhinitis, asthma, prevalence, risk factors.

Study selection: Human studies published in the English language since 1978, especially studies of relatively large populations in the United States, Great Britain, Australia, and New Zealand, with cross referencing to earlier relevant studies.

Results: Current prevalence of allergic rhinitis at 16 years of age in cohorts of British children born in 1958 and 1970 increased from 12% in the earlier cohort to 23% and in the later cohort. Local surveys of allergic rhinitis at approximately 18 years of age in the United States in 1962 to 1965 disclosed prevalence of 15% to 28%, while the national survey of 1976 to 1980 disclosed a prevalence of 26%. Thus, it is uncertain whether prevalence of allergic rhinitis has changed in the United States based on these limited data.

Data from several sources indicate worldwide increases in prevalence of asthma. Annual Health Interview surveys indicate increases in prevalence of asthma in the United States from 3.1% in 1980 to 5.4% in 1994, but prevalence among impoverished inner city children has been much higher. Combined prevalence of diagnosed and undiagnosed asthma among inner city children has been 26% and 27% at 9 to 12 years of age in Detroit and San Diego. Positive family history and allergy are important risk factors for allergic rhinitis and asthma. Prognosis is guarded; allergic rhinitis resolves in only 10% to 20% of children within 10 years, and at least 25% of young adults who have had asthma during early childhood are symptomatic as adults.

Conclusion: Increases in prevalence remain unexplained, but avoidance of recognized allergens should reduce the prevalence of allergic rhinitis and asthma.


INTRODUCTION

Estimates of prevalence of allergic rhinitis and asthma have varied with the populations studied, definitions of the conditions, and methods of diagnosis. Various studies indicate increasing prevalence of both conditions and substantial associated morbidity.

Prevalence is the percent of people in a population with the condition at a given time; current prevalence is the percent with symptoms during the previous 12 months unless another period is indicated. Incidence rate is the percent of new cases of the condition within the specified period. Cumulative prevalence is the percent of people who ever have had the condition.

In 1963 a questionnaire survey of eighth and twelfth grade students attending Denver public schools disclosed current prevalence of hay fever in 19% (16% of eighth grade students and 22% of twelfth grade students) with nonseasonal rhinitis in an additional 6.4% (7.3% of eighth grade students and 5.6% of twelfth grade students). Current prevalence of asthma was 2.8% (2.2% of eighth grade students and 3.3% of twelfth grade students.)

Broder et al2 reported prevalence of allergic rhinitis and asthma in a community in Michigan based upon interviews followed by physical examinations in 1962 to 1965. Allergic rhinitis was defined as a report of hay fever, sinus trouble, or persistent nasal symptoms with at least two of three other features: (1) association with itching of eyes, nose, or throat or burning, watering, or redness of eyes, (2) attribution to exposure to allergen, (3) diagnosis of hay fever or allergic rhinitis by the examining physician. A diagnosis of “suspect allergic rhinitis” was established by a report of hay fever, sinus trouble, or persistent nasal symptoms with either attribution to allergenic exposure or diagnosis by the examining physician or alternatively by a report of hay fever with the associated symptoms described (feature 1). Sinus trouble or persistent nasal symptoms were accepted as indicative of allergic rhinitis only when the diagnosis also was confirmed by the physician.

Asthma was defined as a report of asthma or wheeze with at least two of three other features: (1) association with attacks of shortness of breath or trouble breathing out, (2) attribution to allergenic exposure, or (3) diagnosis of...
asthma or asthmatic or wheezy bronchitis by the examining physician. A diagnosis of “suspect asthma” was established by asthma reported in association with only one of these three features or when wheeze was reported associated with either exposure to allergen or diagnosis by the examining physician or reported in association with both attacks of shortness of breath or trouble breathing out.²

Most previous and subsequent surveys have utilized much less rigorous criteria for allergic rhinitis and asthma, often relying upon the subject’s report of the diagnosis, whether or not established previously by a physician.

Completion of interviews and examinations for 82% of the population of the Michigan community disclosed peak current prevalence of allergic rhinitis at 16 to 24 years of age (12% of men, 12.5% of women) with suspect allergic rhinitis in an additional 3.2% of men and 3.1% of women.² Cumulative prevalence of allergic rhinitis for men peaked also at 16 to 24 years of age at 16.3% with suspect allergic rhinitis at 3.8%. Cumulative prevalence of allergic rhinitis peaked for women at 25 to 34 years of age at 15.3% with suspect allergic rhinitis in an additional 3.9%.²

Current prevalence of asthma in males peaked at 10 to 15 years of age at 6% with suspect asthma in an additional 1.9%, but cumulative prevalence in this age group was 10.7% with suspect asthma in an additional 4.4%.² Current prevalence of asthma in girls 10 to 15 years old was only 3.7% with suspect asthma in 1.1% and cumulative prevalence 7.6% (and suspect asthma in an additional 3.6%). Current prevalence of asthma peaked for women at 25 to 34 years of age at 5.2% with suspect asthma in an additional 4.6% and cumulative prevalence of 7.4% with suspect asthma in a further 6.8%.²

The National Health Interview Survey of 1988 disclosed a prevalence of hay fever of 9.3% in the United States.³ Data from a 1993 self-administered questionnaire survey of 1065 respondents representing a nationally distributed base population of 22,285 (92% white)⁴, however, indicated prevalence of physician-diagnosed hay fever in 8.2%, rhinitis in 4.2%, and persistent stuffy nose in 5.7% for a total of possible allergies affecting the eyes, nose, or throat of 18.3%.⁴ A total of 31.5% of the respondents reported at least 7 days of nasal or ocular symptoms within the previous 12 months; 17.7% reported at least 31 days of symptoms. Self-diagnosed allergic rhinitis was reported by 14.2% (seasonal rhinitis by 8.8%, perennial allergic rhinitis by 5.4%). Prevalence of allergic rhinitis by region ranged from 11.7% in the East North Central region (Illinois, Indiana, Ohio, Michigan, and Wisconsin) to 20.2% in the Mountain Region (Idaho, Montana, Nevada, Utah, Colorado, Arizona, and New Mexico). Prevalence of at least 7 days of nasal or ocular symptoms within the previous 12 months ranged from 27.9% in the West North Central Region (North and South Dakota, Minnesota, Iowa, Missouri, Kansas, and Nebraska) to 38.2% in the West South Central states (Arkansas, Louisiana, Oklahoma, and Texas).

Prevalence of allergic rhinitis may be even higher in some locales. The Tucson Children’s Respiratory Study disclosed 42% of 747 children followed for their first 6 years of life from 1986 to 1990 had physician-diagnosed allergic rhinitis.³ It had been diagnosed in 7% by 6 months of age and an additional 14% by 12 months of age. Of those with the onset of allergic rhinitis during their first year, 77% still had allergic rhinitis at 6 years of age, compared with 57% of those with the onset of allergic rhinitis after the first year.⁴

Longer follow-up would have disclosed further increases in prevalence. The second National Health and Nutrition Examination Survey (NHANES II), a representative national sample of the noninstitutionalized civilian population of the United States in 1976 through 1980, included 4,295 whites, 6 to 24 years of age.⁶ Prevalence of self-reported allergic rhinitis increased with age from 6% at 6 to 11 years of age to 9% at 18 to 24 years of age. Allergic rhinitis was defined as physician-diagnosed hay fever that was active or frequent nasal or ocular symptoms that had varied by season and pollen exposure during the previous 12 months apart from colds or the flu. Prevalence of chronic rhinitis increased from 15% at 6 to 11 years of age to 17% at 18 to 24 years of age. Chronic rhinitis was defined as frequent nonseasonal nasal or ocular symptoms. Allergy prick testing with 8 unstandardized extracts of inhalant allergens confirmed that chronic rhinitis can be due to allergy. Prevalence of chronic rhinitis increased significantly with positive skin tests to house dust, cat, or dog, although after adjustment for sex, age, smoking, region and other reactions, significantly only for dog.

WORLDWIDE VARIATIONS IN PREVALENCE

The International Study of Asthma and Allergies in Childhood (ISAAC) has included prevalence surveys among representative samples of schoolchildren in various locations throughout the world. The subjects included 257,800 children 6 to 7 years of age from 91 centers in 38 countries and 463,801 children 13 to 14 years of age from 155 centers in 56 countries.⁷ The 13 and 14-year-old children and parents of the 6 and 7-year-old children completed written symptom questionnaires translated from English into the local language of each. Rhinitis was defined as sneezing or a runny or blocked nose not due to a cold or the flu. There were additional questions about associated itchy, watery eyes, timing of symptoms within the previous 12 months, extent of interference with daily activities, and whether the child ever had had hay fever.

The prevalence of rhinoconjunctivitis in 1997 at 6 to 7 years of age varied from 0.8% to 14.9% and at 13 to 14

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years of age, from 1.4% to 39.7%. Prevalence was lowest in parts of eastern Europe and south and central Asia. Highest prevalences at 6 and 7 years of age were found in Australia, Hong Kong, New Zealand, South Korea, Taiwan, Thailand, Argentina, Brazil, Chile, Costa Rica, Canada, Portugal, and Poland. Highest prevalences at 13 and 14 years of age were found in Argentina, Australia, Brazil, Canada, Finland, France, Hong Kong, India, Malta, Nigeria, Paraguay, Peru, Spain, the United Kingdom, and the United States (rhinitis within the past year in 34% and 41% at two different sites in Chicago and 30% in Seattle). The authors acknowledge that “dialect and familiarity with the written language may lead to spurious differences in responses even when language is held constant” and cultural factors independent of language may affect awareness and reporting of symptoms. Confirmation by surveys of objective measures of allergic sensitization and evaluation of subsequent trends have been proposed. These preliminary observations suggest substantial worldwide variations in prevalence of allergic rhinoconjunctivitis that may provide important clues to risk factors, as the authors conclude. Another possible explanation for reports of low prevalence in some populations may be the assertion of Amartya Sen that “a population that has little experience of medical care and widespread health problems as a standard condition of existence can have a very low perception of being medically ill.”

Questionnaire surveys of parents of all 11,195 children born in England, Wales, and Scotland during 1 week of March 1958, and the 9,387 born 1 week of April 1970, disclosed at 16 years of age increases in 12-month period prevalence of allergic rhinitis or hay fever from 12.0% in the earlier cohort to 23.3% in the latter (prevalence ratio 1.93, 95% confidence interval 1.82 to 2.06). Prevalence of eczematous rashes increased from 3.1% in the earlier cohort to 6.4% in the later cohort (prevalence ratio of the second to the earlier rate 2.04, 95% confidence interval 1.79 to 2.32).

**RISK FACTORS FOR RHINITIS**

The best established risk factor for allergic rhinitis is a family history of allergy, especially allergic rhinitis. After adjustment for potential risk factors, the British cohort study disclosed prevalence of hay fever at 16 years of age was higher for boys than girls (odds ratio 1.19, 95% confidence interval 1.09 to 1.29, \( P < .001 \)) but lower for children of mothers who had smoked during pregnancy (odds ratio 0.87, 95% CI 0.79 to 0.95, \( P < .01 \)). There were significant trends with decreasing birth order, increasing duration of breast feeding, increasing maternal age, and higher social class. Odds of hay fever were 40% lower for the lowest social class than the highest class, nearly three times as high for a firstborn child as compared with the fifth or later born child, and 20% higher for babies breast fed for more than 1 month than for bottle fed infants.

The Tucson Children’s Respiratory Study, on the other hand, disclosed onset of physician-diagnosed allergic rhinitis in the first 6 months of life was significantly more common among infants who received foods other than breast milk during their first 2 months. Maternal smoking of at least 20 cigarettes per day approached significance as a risk factor during the first 6 months (\( P = .06 \)). Risk factors for allergic rhinitis at 6 years of age included parental allergy, maternal asthma, a dog in the household and serum IgE > 100 IU/mL.

The increased prevalence of asthma, hay fever, atopic sensitization, and bronchial hyperresponsiveness in West Germany as compared with East Germany has invited further investigation. Questionnaires completed by the parents of 9 to 11-year-old children followed by allergy prick testing and isocapnic hyperventilation with cold air disclosed current asthma in 5.9% of the children in West Germany but only 3.9% of children in East Germany; hay fever in 8.6% in West Germany compared with 2.7% in East Germany; positive skin tests to at least one of six allergens in 36.7% in West Germany but only 18.2% in East Germany. Lifetime prevalence of physician-diagnosed bronchitis was higher in East Germany than West Germany (33.7% compared with 15.9%, \( P < .0001 \)). Data from ISAAC questionnaires collected in 1994 and 1995 from Münster, West Germany and Greifswald, East Germany have been compared and analyzed for risk factors for children 5 to 8 and 12 to 15 years of age.

An earlier survey of 9 to 11-year-old Bavarian schoolchildren had disclosed significant reductions in risk of hay fever (odds ratio 0.57, 95% confidence interval 0.34 to 0.98) and at least one positive skin test to a panel of common aeroallergens (OR 0.67, 95% CI 0.49 to 0.93) in homes where coal or wood was used for heating. Coal and wood heating are reported to increase the risk of respiratory infections for reasons that are uncertain.

Strachan has also inferred a protective effect of respiratory infections against allergic rhinitis from the decreased prevalence of hay fever with increasing family size, an effect greater with increased numbers of older siblings than younger siblings in the British cohort studies. A random survey of 15,000 British adults 20 to 44 years of age also disclosed a negative association of prevalence of hay fever with family size and birth order as well as a negative association between symptoms of asthma and family size. Martinez has observed repeated viral infections in early life.
might enhance development of Th1 cells, inhibiting proliferation of Th2 clones, which otherwise would produce IL-4, one of the signals that induces B cell clones to switch from production of IgM to IgE. Increased exposure to infections in older siblings, increased prevalence of bronchitis, and increased infections associated with heating with coal and wood might thus afford protection against allergy and asthma. A protective effect of infectious disease might also account in part for very low prevalence of allergic rhinitis and asthma in some countries.

Others also have found associations between vehicular traffic and allergic rhinitis and asthma. Prevalence of Japanese cedar pollinosis has been associated with intensity of exposure to automobile exhaust fumes.18 Prevalence of wheezing and allergic rhinitis has correlated with exposure to truck traffic in Germany.19,20 Peterson and Sax on21 have reviewed some of the evidence that polyaromatic hydrocarbons in diesel exhaust particles can enhance production of IgE.

Although a few studies have indicated associations between environmental exposure to tobacco smoke and numbers of positive allergy prick tests,22,23 a recent review of 36 studies disclosed no overall significant association of passive smoking with skin test positivity, total serum IgE concentrations, or allergic rhinitis or eczema.24

Allergy is part of the definition of allergic rhinitis.5,6,11,23,25 and it may therefore seem puzzling that feather bedding might have a protective effect, as reported from Germany.13 House dust mite allergens, however, are among the allergens associated most commonly with allergic rhinitis in most of the world.6,11,23 and the concentration of Der p I allergen in synthetic pillows may be eight times as high as that in feather pillows.26,27

High humidity fosters proliferation of dust mites and growth of mold.28,29 and damp housing has been associated significantly with sensitization to mites30 and prevalence of allergic rhinitis, asthma, and eczema.31 Although onset of allergic rhinitis within the first 6 months of life was associated with early introduction of foods other than breast milk in the Tucson Children’s Respiratory Study, later onset of allergic rhinitis was not,3 and the British cohort study disclosed no protective effect of breast feeding.9 Some studies have indicated avoidance of cow milk and other allergenic foods during the first 6 months of life reduced subsequent frequency of allergic rhinitis, asthma, and atopic dermatitis,32–35 but other studies have failed to confirm this.23 A prospective, randomized, controlled study of avoidance of allergenic foods in infancy in 103 children with 185 control children, with follow-up of 57% of both groups at 7 years of age, disclosed no difference in prevalence of allergic rhinitis, asthma, atopic dermatitis, or food allergy at 7 years of age.23 Mothers of infants in the experimental group avoided cow milk, egg, and peanut during the last trimester of pregnancy and during lactation, and the infants avoided cow milk during the first year, egg during the first 2 years, and peanut and fish during the first 3 years. Some received a casein hydrolysate during the first year. Breast feeding “for at least 4 to 6 months” was recommended to both groups. There was a significant reduction in prevalence of food allergy and allergy to cow milk during the first 2 years in the prophylactic group. Children with food allergy by 4 years of age did have higher prevalences of allergic rhinitis and asthma at 7 years of age.

Another study with longer follow-up did disclose a protective effect of avoidance of cow milk.36 The authors studied 236 infants born in Helsinki, Finland in 1975, and divided into three groups on the basis of duration of breast feeding of at least 6 months, 1 to 6 months, or less than 1 month. Infants were examined periodically during the first year and at 3, 5, 10 and 17 years of age. Evaluation of 150 children continued through 17 years of age. Atopy (allergic rhinitis, asthma, atopic eczema, or food allergy) was present in 20% at 1 year of age and increased to 47% at 17 years of age. Cumulative prevalence of atopy was 67% at 17 years of age. Prevalence of atopy was significantly increased in the group that had had little or no breast feeding. Food allergy at 1 to 3 years of age was highest in that group, and respiratory allergy was most frequent in that group (65% at 17 years of age compared with 43% or less in those breast fed for at least 1 month).

The increased prevalence of allergic rhinitis in higher social classes observed in the British cohort study agrees with some other studies,2,36 and the Tucson Children’s Respiratory Study indicated a higher prevalence of allergic rhinitis among children whose mothers had more than a high school education.5 Others have found associations between prevalence of positive allergy skin tests and higher social classes or correlation with levels of education and income,38 observations that remain unexplained.

PROGNOSIS OF ALLERGIC RHINITIS

Prognosis affects prevalence of course. Although the Tucson Children’s Respiratory Study disclosed that 23% of children with onset of allergic rhinitis in their first year experienced remission by 6 years of age,3 and Pedvis et al39 observed remissions within 12 years in 18% of 143 children with allergic rhinitis, Linna et al40 found complete resolution of allergic rhinitis in only 10% of 154 children 8 to 11 years later. These children were 3 to 17 years of age at the time of initial diagnosis. Asthma or wheezing had occurred in 19% by the time of follow-up.

CHANGING PREVALENCE OF ASTHMA

Annual Health Interview Surveys have disclosed increases in self-reported prevalence of asthma in the United States from 30.7 per 1,000 in 1980 to 53.8 in 1993–94 (Fig 1).42 Rates have been higher for blacks than whites, increasing from 34.0 per 1,000 in 1980 for blacks to 57.8 in 1993–1994, compared with increases for whites from 30.4 to 50.8. Increases across time
have occurred in all age groups, but the greatest proportionate increase has occurred in children less than 5 years of age with a 160% increase from 22.2 per 1,000 in 1980 to 57.8 in 1993–1994. For children 5 to 14 years of age, prevalence increased from 42.8 per 1,000 in 1980 to 74.4 in 1993–1994, an increase of 74%. Increases in prevalence occurred in all four regions of the country.

Treated prevalence of asthma among members of a large health maintenance organization in the Pacific Northwest also increased from 1967 to 1987 among both males and females in all age groups except men 65 years of age and older. Approximate increases for boys and girls less than 15 years of age were from 1.2% to 3.5% and 0.7% to 2.2%, respectively. During the years of the study, enrollment in the plan increased from 86,200 to 310,800. Observed parallel increases in chronic airflow obstruction, which included chronic bronchitis and emphysema as well as asthma, argue against diagnostic transfer as the explanation of the apparent increase in prevalence of asthma. The authors acknowledge limitations to the generalizability of these data from a population with underrepresentation of the extremes of wealth and exclusion of visits for asthmatic bronchitis. Nevertheless, these observations do support real increases in prevalence of asthma.

Other national data from the National Center for Health Statistics indicate increases in cumulative prevalence of asthma at 6 to 11 years of age in 1976 to 1980 as compared with 1971 to 1974 (Table 1). The second National Health and Nutrition Examination Survey of 1976 to 1980 also indicated a higher prevalence of physician-diagnosed current asthma and/or wheezing at 3 to 17 years of age in boys than girls (7.8% versus 5.5%, $P < .01$) and higher prevalence among black children than white (9.4% versus 6.2%, $P < .01$). Prevalence also was greater among children living in urban areas compared with rural areas (7.1% versus 5.7%, $P < .05$).

Child Health Supplements to the 1981 and 1988 Health Interview Surveys provided data about one randomly selected child in each household representative of the civilian noninstitutionalized population of the United States. There were data for 15,224 children and young people less than 18 years of age in 1981 and 17,110 in 1988. When asked whether the child ever had asthma and whether it had been present in the previous 12 months, parents indicated a significant increase in prevalence of current asthma from 3.1% in 1981 to 4.3% in 1988 (Table 2).

Subsequent more limited surveys have suggested further increases in prevalence of asthma among inner city children. In 1991 a random digit dialing telephone survey in Bronx County, New York disclosed 14.3% of 1285 children less than 18 years of age had...
had asthma at some time in the past, 8.6% had had asthma within the previous 12 months, and an additional 4.2% had had wheezing within the previous 12 months without diagnosed asthma.45 Thus, current prevalence of asthma probably was 12.8%. This sample included 52% Hispanic, 30% black, and 14% white children.

Questionnaires completed in 1991 to 1994 by parents of 998 fourth grade students, 9 to 12 years of age, in an impoverished area of San Diego disclosed probable current asthma in 14.7% with possible asthma related symptoms in an additional 12.5%.46 Probable asthma was defined as a history of wheezing or physician-diagnosed asthma with symptoms during the previous year or use of medications for relief of symptoms. Possible asthma-related symptoms were inferred from the presence of at least two of the following symptoms: breathlessness, chest tightness, cough, mucous production, or congestion. Of these children 68% were Hispanic, 17% black, 9% Asian, and 4% white. Only 57% of the Hispanic children with probable asthma had physician-diagnosed asthma compared with 81% of the black children and 86% of the white children, possibly partly due to the lower rate of insurance coverage for the Hispanic children (37% compared with 70% for black children and 80% for white children).

A 1993 survey of 230 Detroit schoolchildren in grades 3 to 5, 98% black, disclosed a cumulative prevalence of physician-diagnosed asthma of 17.4% and current prevalence of 14.3% with undiagnosed asthma in an additional 11.7%.47 Undiagnosed asthma was established in 11 children by decreases in FEV1 of at least 15% after a 9-minute step test and in another 16 children by modified American Thoracic Society criteria. These criteria comprised three or more episodes of wheezing or “persistent coughing” during the previous 12 months. Thus, the total prevalence of current asthma using these criteria was 26%.

### Table 2. Estimated Current Prevalence of Asthma (%) by Age, Sex, Race, Family Income, Urbanization, and Birth Weight

<table>
<thead>
<tr>
<th>Subgroups</th>
<th>1981*</th>
<th>1988*</th>
<th>Relative Risk</th>
<th>95% CI†</th>
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<td>4.3</td>
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<td>2.9</td>
<td>4.1</td>
<td>1.4</td>
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* Rates based on data from 1981 and 1988 Child Health Supplements to National Health Interview Surveys.
† CI = confidence interval.

**WORLDWIDE PREVALENCE OF ASTHMA**

The ISAAC Steering Committee has reported 12-month prevalence of symptoms of asthma among children 13 to 14 years of age as indicated on written questionnaires varied from 1.6% to 36.8%.48 Highest prevalences were reported from the United Kingdom, New Zealand, Australia, Republic of Ireland, followed by most centers in North, Central, and South America. Lowest prevalences were found in Indonesia, several Eastern European countries, Greece, China, Taiwan, Uzbekistan, India, and Ethiopia. In 99 centers in 42 countries, 304,796 children participated, the written questionnaires were supplemented by video asthma questionnaires to demonstrate signs of asthma. The rank correlation between center prevalences for the written and video questionnaires was 0.76 (P < .0001) although prevalences were somewhat lower on the video questionnaire, which asked about more severe symptoms than the written questionnaire.

The European Community Respiratory Health Survey of 48 centers, mostly in Western Europe, also disclosed wide variations in current prevalence of wheezing and asthma.49 Prevalence of wheezing in the previous 12 months at 20 to 44 years of age varied from lows of 4.1% in India, 4.2% in Algeria, and 8.5% in Pavia, Italy to 25.7% in Portland, Oregon, 27.3% in New Zealand, 28.8% in Australia, 29.8% in the United Kingdom, and 32.0% in Dublin, Ireland. Prevalence of diagnosed asthma varied from 2.0% in Estonia (where prevalence of wheezing was reported by 26.8%), and 2.1% in Germany and Spain to 7.1% in Portland, Oregon, 8.4% in the United Kingdom, 11.3% in New Zealand, and 11.9% in Australia.

Prevalence of wheezing in the previous 12 months at 12 to 14 years of age in 1995 in 93 secondary schools in Great Britain was 33.3% although...
prevalence of ever having been diagnosed with asthma was only 20.9%. Cumulative prevalence of wheezing was 48.8%. Prevalence of current wheezing was slightly higher in Scotland than England (36.9% compared with 32.3%), and slightly higher in nonmetropolitan than metropolitan areas (35.0% versus 30.3%), but there were no other substantial geographic variations, suggesting a lack of major impact of climate, diet, or outdoor environment, which vary geographically in Great Britain. Prevalence of wheezing was lower in children born outside Great Britain but currently residing there, suggesting a role of environment in infancy.

A 1992 nationwide British survey of 5,472 children 5 through 17 years of age disclosed 15.0% had wheezed in the previous year. Cumulative prevalence of wheezing disclosed 15.0% had wheezed in 5,472 children 5 through 17 years of age from 1965–1975 cohort to 4.6% in the 1978–1988 cohort. Age-specific prevalence of asthma without associated hay fever or eczema increased more between the two periods than asthma with hay fever or eczema. The authors infer possible changes in causes of asthma, at least in Norway.

Data from questionnaire surveys of schoolchildren 6 to 16 years of age in Oslo, Norway in 1981 and 1994 were analyzed as historical cohorts to estimate age-specific prevalence and incidence of asthma with and without hay fever or eczema. Point prevalence of asthma at 3 years of age increased from 1.9% in the 1965–1975 cohort to 4.6% in the 1978–1988 cohort. Age-specific prevalence of asthma without associated hay fever or eczema increased more between the two periods than asthma with hay fever or eczema. The authors infer possible changes in causes of asthma, at least in Norway.

Data from Australia also suggest nonatopic causes may be important in increasing prevalence of asthma. Questionnaire surveys of 8 to 10-year-old children in the dry, inland community of Wagga Wagga and the humid, coastal community of Belmont in 1982 and 1992 disclosed increases in prevalence of wheezing and airway hyperresponsiveness with no change in prevalence of atopy. In Wagga Wagga, diagnosed asthma increased from 12.9% in 1982 to 29.7% in 1992, wheezing within the previous 12 months increased from 15.5% to 23.1%, and hay fever increased from 29.0 to 43.2%. In Belmont, prevalence of asthma increased from 9.1% to 37.7%; wheezing, from 10.4% to 27.6%; and hay fever, from 20.5% to 34.0%. Prevalence of airway hyperresponsiveness (20% decrease in FEV1 after histamine inhalation) increased in Wagga Wagga from 11.7% in 1982 to 18.1% in 1992, while that in Belmont increased from 9.1% to 19.8%. Prevalence of ever having been diagnosed with asthma was only 20.9%.

RISK FACTORS FOR ASTHMA

Heredity

A history of asthma in the immediate family is the best recognized risk factor for asthma. As early as 1650, Sen-
parents recognized that asthma could be familial.60

Parents of a cohort of 770 children 5 to 9 years of age in East Boston, Massachusetts completed annual questionnaires for 11 of the 13 years of follow-up.61 Relative risk for asthma was 1.95 (95% CI 1.29 to 2.95) if a parent had had asthma and also was increased significantly if a parent had either eczema or hay fever during the period of the study (relative risk 1.61, 95% CI 1.03 to 2.50). Other significant risk factors for the 91 children with asthma were antecedent hay fever, pneumonia, bronchitis, and sinusitis.61

Others have confirmed the increased risk for asthma in children of parents with asthma.62-64 Questionnaires completed in 1992–1993 by parents of 729 children 6 to 14 years of age in the United Arab Emirates disclosed a prevalence of asthma of 12%.62 Maternal asthma conferred a relative risk of 2.67 (95% CI 1.65 to 4.35); paternal asthma, 2.85 (1.81 to 4.49). Maternal but not paternal allergic rhinitis also increased risk of asthma significantly in the child.

A study of 306 children from 217 Boston families with at least one parent with physician-diagnosed “asthma, hay fever, or allergies,” aged 1 to 24 years (median 3.5 years), disclosed increasing prevalence of asthma with age.63 Prevalence of asthma was 8.2% for children less than 5 years of age, 17.9% at 5 to 10 years of age, and 31.6% for those older than 10 years of age. The multivariable odds ratio for asthma when the mother had asthma was 4.1 (95% CI 1.7 to 10.1); that for paternal asthma, 2.7 (1.0 to 7.2). Among children less than 5 years of age risk for asthma associated with maternal asthma (odds ratio 5.0, 95% CI 1.7 to 14.9) was greater than the risk associated with paternal asthma (OR 1.6, 95% CI 0.5 to 5.9). Parental hay fever or eczema did not significantly increase the risk of asthma in the child, but either maternal or paternal eczema increased the risk of eczema in the child significantly. The risk of a child with asthma was increased 3-fold by one asthmatic parent and 6-fold by two asthmatic parents as compared with families with only one parent with inhalant allergy but no asthma.65 These observations suggest different modes of inheritance for asthma and other atopic diseases.

A study of 9,349 schoolchildren 9 to 11 years of age in Munich and Southern Bavaria also confirmed an increased risk of asthma when a parent had asthma (odds ratio 2.6, 95% CI 1.7 to 4.0), but a significant risk only when the father had asthma (OR 4.4, 95% CI 2.5 to 7.8; odds ratio for maternal asthma 1.5, 95% CI 0.7 to 2.7). Parental allergic rhinitis or atopic dermatitis did not increase the risk of asthma in the child, but parental allergic rhinitis did increase the risk of allergic rhinitis and parental atopic dermatitis increased the risk of atopic dermatitis in the child.64

Studies of twins have confirmed roles of both heredity and environment in determination of asthma. Analysis of questionnaire data from 5,864 Norwegian twins 18 to 25 years of age disclosed a relative risk of 17.9 (95% CI 10.3 to 31.0) when an identical twin had asthma and 2.3 (95% CI 1.2 to 4.4) when a fraternal twin had asthma as compared with pairs where the co-twin had no asthma.65 The authors concluded genetic effects accounted for 75% of the variation in risk for asthma.

Allergy

Allergy also is well established as a risk factor for asthma. Study of 2,657 adults and children at least 6 years of age in Tucson disclosed a highly significant relationship between prevalence of self-reported asthma and serum IgE concentration, standardized for age and sex.66 There was no asthma in the 177 subjects with the lowest IgE levels (>1.46 SD below the mean for age and sex).

Allergy prick testing of 4,295 subjects 6 to 24 years of age who provided data for the second National Health and Nutrition Examination Survey of 1976–1980 disclosed significant associations between asthma and reactivity to house dust and Alternaria.6 Allergic rhinitis was associated also with reactivity to ragweed and ryegrass.

Allergy prick testing with 13 inhalant allergens in 380 Australian schoolchildren in 1982, when they were 8 to 10 years of age, and again 2 and 4 years later disclosed increases in prevalence of at least one positive skin test from 24% to 39%.67 Allergy at 8 to 10 years of age was a risk factor for asthma, wheezing, and bronchial hyperresponsiveness.

The association of current asthma with increased serum IgE concentrations was confirmed by a study of 1,916 adults, 20 to 44 years of age, in Spain.68 The odds ratio for asthma with total IgE >100 kU/L was 4.73 (95% CI 2.01 to 11.12) after adjustment for sex, age, smoking status, geographic area, and specific IgE to Dermatophagoides pteronyssinus, cat allergen, timothy, Cladosporium, and Parietaria. Of the subjects with asthma, 70% had bronchial hyperresponsiveness, and the association of current asthma and bronchial hyperresponsiveness with total serum IgE also was significant (OR 3.62, 95% CI 1.03 to 12.64).68

Asthma in 11-year-old children in New Zealand was associated with total serum IgE concentrations.69 Current asthma and current wheezing were defined in this study by symptoms within the previous 2 years, unlike most other studies, where current asthma has been asthma within the previous year. When studied in 1983 prevalence of “current asthma” was 13% among 410 boys and 6% among 374 girls, and prevalence of current wheezing not diagnosed as asthma was 22% among the boys and 15% among the girls.69 Serum IgE concentrations exceeded 32 IU/mL in all children with current asthma (geometric mean 456.6, 95% CI 351.0 to 617.6, P < .0001 as compared with children with no asthma). Airway hyperresponsiveness to methacholine also correlated significantly with serum IgE levels, both in children with current asthma and in those with current wheezing, and even in those with no histories of asthma or wheezing.

Bronchial biopsies of asthmatic subjects have disclosed increased expres-
sion of mRNA encoding IL-4 and IL-5 and increased numbers of IL-4 and IL-5-immunoreactive cells as compared with normal controls, irrespective of whether the asthmatic subjects had positive prick tests to at least one aeroallergen. These observations further implicate these Th2 cytokines in the immunopathogenesis of asthma with or without identifiable specific allergy.

On the other hand, allergy to some specific allergens has been identified as a risk factor for asthma. Prospective study of 67 British children at risk for allergy because of a parent with asthma or hay fever, identified intense exposure to house dust mites in early childhood as a risk factor for asthma. By 11 years of age, 35 children had positive skin tests to at least one of six allergens and 42 had histories of wheezing, including 26 of the 35 atopic children. At 11 years of age 23 of the children had bronchial hyperresponsiveness to histamine, and 17 of these had wheezed in the previous year and were classified as having asthma. Sixteen of these 17 were atopic and sensitized to *D. pteronyssinus*. Analysis of house dust samples collected in the homes of the children when they were 1 to 2 years of age disclosed no child exposed to less than 2 μg Der p 1 per gram of dust had become sensitized by 11 years of age. All but one of the children with current asthma at 11 years of age had been exposed at 1 year of age to more than 10 μg Der p 1 per gram of dust, which conferred a relative risk of asthma of 4.8.

Collection of dust samples from homes in six different regions of Australia has disclosed a dose response relationship between exposure to Der p 1 and prevalence of current asthma in 8 to 11-year-old children. Asthma was defined by wheezing within the previous year and bronchial hyperresponsiveness to histamine.

Studies of 3,581 children 8 to 11 years of age in three different areas of Australia disclosed significant associations of wheezing within the previous year, bronchial hyperresponsiveness, and hay fever with at least one positive prick test to a group of 13 aeroallergens (*D. farinae, D. pteronyssinus*, “house dust,” cat, dog, horse, feathers, timothy, rye, ragweed, plantain, *Alternaria tenuis*, and *Aspergillus fumigatus*). In 95% to 97% of the atopic children there was sensitization to at least one of seven allergens: house dust, *D. farinae, D. pteronyssinus*, cat, plantain, rye, and *Alternaria tenuis*. Sensitivity to dust mites had the strongest independent association with current asthma (bronchial hyperresponsiveness and wheezing within the previous year) in all three areas. Associations of current asthma with sensitivity to cat were significant in two of the three areas; with plantain, in two areas; and with rye and Alternaria, in one area each, a dry inland pollen region with high seasonal pollen peaks. Risk of asthma also has been associated primarily with sensitization to house dust mites and cat in 13-year-old children in New Zealand. Prevalence of asthma within the previous 2 years was 10.6% (12.9% of boys and 8.1% of girls) of the 662 children with a cumulative prevalence of 18.6% (21.7% of boys and 15.3% of girls). Prick testing with 11 allergens elicited at least one positive reaction in 43.8% of the children (50% of boys, 37% of girls). Nineteen percent of the children were sensitive to *D. pteronyssinus* or cat and an additional 11% were sensitive to both mite and cat. Sensitivity to each of the 11 allergens was more frequent in boys than girls, and prevalence of four or more positive skin tests was more than twice as great in boys than girls (8.5% compared with 4%). Cat or mite sensitivity significantly increased the risk of asthma within the previous 2 years. The increased rates of sensitization among boys may have accounted for the increased prevalence of asthma among boys at least in part. Grass sensitivity, which was more frequent than mite sensitivity, was more closely related to hay fever than to asthma; 51.7% of children sensitive only to grass had hay fever, while 11.3% of children sensitive only to mite had hay fever.

The 1976 to 1980 national survey of children and young adults 6 to 24 years of age in the United States (NHANES II) disclosed increased prevalence of positive prick skin tests to Alternaria, house dust, dog, Bermuda grass, oak, ragweed and rye grass among those with physician-diagnosed asthma, but after adjustment for sex, age, smoking, region, and other reactions, only Alternaria (OR 5.1, 95% CI 2.9 to 8.9) and house dust (OR 2.9, 95% CI 1.7 to 5.0) remained significant as compared with negative reactors.

Determination of specific IgE by RAST to five allergens in patients treated for acute asthma in a Virginia emergency room, however, disclosed significantly increased prevalence of hypersensitivity at less than 50 years of age as compared with patients visiting the emergency room for other conditions. Prevalence of specific allergy to *D. farinae*, cockroach, cat, ragweed, or rye grass was fourfold greater among the patients treated for asthma. Five of the six patients with predominant sensitivity to grass pollen visited the emergency room during the grass pollen season.

Subsequent study of 114 patients 15 to 55 years of age, who required treatment for acute asthma in emergency rooms in Wilmington, Delaware, confirmed increased serum concentrations of specific IgE to *D. farinae, D. pteronyssinus*, cat, and cockroach as compared with age and sex-matched controls who visited the emergency rooms for other reasons. Analysis of dust obtained from homes for presence of mites, cat, and cockroach allergens permitted comparison to serum specific IgE concentrations; the combination of cat or cockroach allergen in the home and sensitization was associated significantly with asthma.

Prick testing and RAST in 40 schoolchildren in central Virginia with symptoms of asthma, 48 with symptoms of asthma and bronchial hyperresponsiveness to histamine, and 123 control children implicated dust mites (*D. farinae, D. pteronyssinus*), cat, cockroach, and tree pollen as risk factors for asthma (OR 6.6, *P* < .0001).
Multivariable analysis, however, identified only mite allergy as a significant risk factor. Analysis of dust samples from homes disclosed mite allergen concentrations >2 μg/g in 81% of homes but cat exposure in less than 40% and cockroach exposure in only 17%.

In Los Alamos, New Mexico, on the other hand, at an elevation of 7,200 feet, dust samples from 109 homes of children 12 to 14 years of age contained mostly high concentrations of dog and cat allergen, consistent with the presence of animals in most homes. Der f I and Der p I concentrations in dust were less than 2 μg/g in 95% of homes, and cockroach (Blattella germanica) was detectable in only 2 homes. Prevalence of specific IgE to dog and cat was increased highly significantly in the sera of 57 children with histories of wheezing as compared with 54 control children (P < .0001 and < .001, respectively) and significantly to Russian thistle pollen (P < .045) but not to mites or cockroach.

Prick testing of 476 asthmatic children, 4 to 9 years of age, from eight inner city areas in the Eastern and Central United States disclosed positive skin tests to cockroach in 36.8%, dust mites (D. farinae, D. pteronyssinus) in 34.9%, cat allergen in 22.7%. Dust samples from their bedrooms contained high concentrations of cockroach allergen in 50.2%, mite allergen in 9.7%, and cat allergen in 12.6%. Children both allergic to cockroach and exposed to high concentrations of cockroach allergen had significantly increased rates of admission to the hospital and unscheduled medical visits for asthma as well as symptoms of asthma. Similar results were not found for allergy with exposure to mites or cat allergen.

A longitudinal study of children in semiarid Tucson, Arizona identified Alternaria alternata as the allergen predominantly associated with asthma. The children, born in 1980 to 1984, were evaluated at 6 and 11 years of age, when prevalence of current physician-diagnosed asthma was 9.8% (N = 948) and 15.5% (N = 895), respectively; prevalence of allergic rhinitis without asthma was 26.2% and 23.2%, and prevalence of allergic rhinitis among those with asthma was 67.7% and 66.9%. Allergy prick tests were most often positive to Bermuda grass among children with allergic rhinitis only or control children with no allergy (34% and 21%, respectively at 6 years of age, 51% and 25% at 11 years of age) compared with 44% and 52% for those with asthma, while positive reactions to Alternaria were most prevalent among children with asthma (50% and 41%). Tests with house dust, D. farinae, and cat were much less often positive in any of the three groups. Logistic regression indicated only Alternaria independently associated with risk for asthma.

Allergy prick testing of 343 children 7 to 12 years of age recruited from a general pediatric practice in Raleigh, North Carolina identified Alternaria tenuis sensitization as a risk factor for recurrent wheezing (OR 6.8, 95% CI 2.1 to 21.5). Logistic regression also identified cat allergen (OR 15.5, 95% CI 3.4 to 70.8) and D. farinae (OR 5.2, 95% CI 3.0 9.0) as risk factors.

Sensitization to Alternaria tenuis also has been identified as a significant independent risk factor for asthma in children in Los Alamos, New Mexico and Charlottesville, Virginia, but not in Atlanta, Georgia or Wilmington, Delaware.

Accordingly, allergy is a risk factor for asthma, but the specific allergens of importance depend upon intensity and probably duration of exposure. Intermittent exposure to a seasonal allergen may not elicit airway inflammation of sufficient duration to cause asthma.

Environmental Tobacco Smoke

Analysis of data from the 1981 Child Health Supplement to the National Health Interview Survey, which included information about 4,331 children less than 5 years of age, indicated an increased risk for asthma for those whose mothers smoked at least one-half pack of cigarettes per day (OR 2.1, P = .001). Such maternal smoking also was a significant risk factor for the children’s use of antiasthmatic medications and for onset of asthma during the first year of life.

Review of published studies of relationship of passive smoking to incidence of asthma, case control studies, and case series describing disease severity has indicated an association of maternal smoking with increased incidence of wheezing up to 6 years of age (pooled OR 1.31, 95% CI 1.22 to 1.41) and less strongly thereafter (OR 1.13, 95% CI 1.04 to 1.22). Four studies suggested parental smoking was associated more strongly with wheezing in nonatopic than atopic children. Severity and frequency of symptoms were associated with exposure to smoke in the home.

Although a link between exposure to smoke and allergic sensitization has been suggested, a systematic review of published studies of the effects of parental smoking on serum IgE concentrations, allergy prick testing, and allergic rhinitis or eczema showed no consistent effect on any of these variables. Although passive smoking can trigger airway obstruction in asthmatic patients, increasing frequency and severity of symptoms, available data overall do not establish conclusively a significant association with allergic sensitization or development of asthma.

Respiratory Infection

Maternal smoking has been associated with increased frequency of lower respiratory tract illnesses, including wheezing, during the first year of life, however. In the Tucson Children’s Respiratory Study, 847 children followed by pediatricians during their first year of life had increased risk of lower respiratory tract illness if the mother smoked (OR 1.52, 95% CI 1.07 to 2.15) with an even greater risk if the mother smoked at least one pack of cigarettes per day and if the child remained at home rather than attending day care (OR 2.8, 95% CI 1.43 to 5.5). Day care use was associated with increased rates of lower respiratory illness for children of nonsmokers.
and light smokers, but not for children of heavy smokers.

Systematic review of published evidence has confirmed a significant relationship between acute lower respiratory illness in the first 3 years of life and smoking by either parent (pooled odds ratio 1.57, 95% CI 1.42 to 1.74) with a slightly higher odds ratio for maternal smoking (OR 1.72, 95% CI 1.55 to 1.91).90 Prospective follow-up, of 826 infants in Tucson at 3 and 6 years of age disclosed 19.9% had had at least one lower respiratory tract illness with wheezing during the first three years of life but no wheezing at 6 years of age, while 13.7% had wheezing both before 3 years of age and at 6 years of age.91 Most of these lower respiratory tract illnesses were due to respiratory syncytial virus or parainfluenza virus. Pulmonary function testing of 125 infants before lower respiratory tract illnesses indicated lower maximal expiratory flow at functional residual capacity in those who subsequently experienced transient wheezing.91 The children who wheezed both before 3 years of age and at 6 years of age were likely to have wheezed “often or very often” (OR 2.3, 95% CI 1.4 to 3.8) and more likely to have wheezed without colds in infancy as compared with those with transient wheezing.91

Although viral respiratory infections frequently trigger acute exacerbations of asthma,92 low prevalence of asthma in populations with high rates of respiratory infection and higher prevalence of asthma associated with very low rates of infection in other populations have suggested a protective effect of infection with respect to asthma and allergic sensitization.17

A retrospective study of young adults who had been adopted within the first 3 months of life disclosed significantly increased risk for asthma when the adoptive mother had asthma (OR 3.2) as compared with families where neither adoptive parent had asthma or allergic rhinitis, suggesting possible mediation by a transmissible agent.93 Earlier studies indicated increased incidence of asthma and allergic rhinitis after marriage to an affected spouse, and prevalence of asthma after entry into their profession has been higher for respiratory therapists than physical therapists.94

Racial and Social Risks
The Child Health Supplement to the 1981 National Health Interview Survey included data from parents of 15,416 children less than 18 years of age. Prevalence of current asthma was significantly greater among black children than white children (4.4% versus 2.5%, P = .0001).95 Prevalence at 2 through 5 years of age was 6.5% for black children and 3.1% for white children. Among children 6 through 17 years of age with onset of asthma after 6 years of age there was no significant difference in rates of asthma, but more than 80% of children with asthma at 6 to 17 years of age had had its onset during the first 5 years of life. Among children 2 to 5 years of age asthma was significantly more common among blacks, among boys, and among those whose mothers smoked at least a half pack of cigarettes per day, those with birth weights less than 2500 g, those with mothers less than 20 years of age at the time of birth, those with mothers with less than a high school education, families with six or more living together, living in a home with less than eight rooms, not living with both parents, and those in extreme poverty. After adjustment for other variables, including race, single-parent household, and extreme poverty, the only variables that were independent significant predictors of asthma were sex, maternal smoking, low birth weight, large family, and small house.95 Race and poverty were no longer significant.

The NHANES II of 1976–1980 included 5,672 children 6 months to 11 years of age. It too, indicated higher prevalence of current asthma (in this case physician-diagnosed asthma) among black children than whites (7.2% versus 3.0%).96 Frequent wheezing also had been more frequent among black children (9.3% versus 6.2%). Identified risk factors included sex, young maternal age, residence in a central city, and poverty (family income less than $9,100 per year, 1988 dollars); after adjustment for these factors, risk of asthma still was increased for black children (OR 1.7, 95% CI 1.2 to 2.1). Frequent wheezing was associated with low birth weight and increased triceps skinfold thickness as well as race and sex. The authors inferred from the significant effects of maternal age and birth weight possible importance of the intrauterine environment for determination of asthma.96

Much of the increased prevalence of asthma among blacks is related to variables other than race, including crowding, which may increase exposure to allergens such as dust mites and cockroach.

Diet
Hypothesized beneficial effects of dietary fish oils and adverse effects of high sodium intake remain unproved. Some studies favor one hypothesis or the other, while others do not.94

PROGNOSIS
Much of the prevalence of asthma is related to prognosis. A cohort of all people born in England, Scotland, and Wales during 1 week of March, 1958 was evaluated for asthma or wheezy bronchitis in the previous year at 7, 11, 16, and 23 years of age and for “wheezing or whistling in the chest” in the previous year at 33 years of age.98

Of the 17,414 infants in the original cohort and 1,145 immigrants born during the same week and subsequently added, 1,046 had histories of asthma or wheezing by 7 years of age, and there was follow-up for 880 of these through 33 years of age. By 7 years of age 18% of the children had had asthma or wheezing, and 49% of those had wheezed during the previous year (Table 3). Only 26% of them had had wheezing the previous year by 33 years of age. During the intervening years some lost their asthma and later experienced recurrence; only 5% had persistent wheezing throughout all periods, while 33% of those who had wheezed during their first 7 years experienced complete remissions (Fig 2). Cumulative incidence of wheezing
by 33 years of age was 43% (Table 3). Active smoking was associated strongly with adult onset of wheezing (OR 4.42, 95% CI 3.31 to 5.92).

These observations agree with two long term Australian studies of prognosis of asthma. A prospective, 25-year study of a Tasmanian birth cohort disclosed 25.6% of those who had had asthma or wheezing by 7 years of age had current asthma at 30 to 32 years of age, and 10.8% of those who had not had childhood asthma also had current asthma. A 28-year follow-up of children in Melbourne who by 7 years of age had had mild wheezy bronchitis (fewer than 5 episodes associated with respiratory infections), wheezy bronchitis (5 or more episodes), or asthma (wheeze not associated with infections) disclosed current asthma in 23% of those with mild wheezy bronchitis, 25% of those with wheezy bronchitis, and 50% of those who had had asthma as young children. Follow-up of 67 children with severe asthma at 10 years of age disclosed 75% still had current asthma at 35 years of age; 63% had wheezed at least weekly during the previous 3 months. Limited data from a prospective survey from Tucson, Arizona completed in 1983 indicated a lower rate of remission of active self-reported asthma at 30 to 60 years of age of only approximately 10% within 9 years. After 60 years of age remission rates increased to more than 20%. Rates of recurrence of asthma in subjects with histories of asthma approximated 40% at 30 to 60 years of age and increased to 67% at 60 to 69 years of age.

A population-based cohort of 3,187 children whose parents completed questionnaires when they were 6 to 8 years of age with follow-up survey of 2,289 at 14 to 16 years of age provided further information about the natural history of respiratory symptoms. Current wheezing, reported for 14.6% in the earlier survey, had increased to 18.2% in adolescence; current coughing had decreased from 16.2% to 12.4%. Of those who had reported current wheezing at 6 to 8 years of age in 1987, 55% had wheezing 8 years later, but 10% of those who never had wheezed at the time of the earlier survey had current wheezing (within the previous year) in 1995. In 1995, 22% of the adolescents had physician-diagnosed asthma, including 80% of the children with current wheezing, 94% of those with current wheezing at the time of both surveys, and 117 (69%) of those with onset of wheezing since the earlier survey.

There were significant associations of hay fever and eczema with physician-diagnosed asthma and persistent wheezing, defined as current wheezing at the time of each of the two surveys. Active smoking was associated with persistent wheezing among boys. There was a negative association between the number of children in the household and persistent wheezing. Onset of wheezing after the earlier survey was associated with hay fever, eczema, active smoking, lower social class, and female sex. Current wheezing, persistent wheezing, physician-diagnosed asthma, and late onset wheezing all were associated with maternal asthma.

None of these studies evaluated effects of treatment, although a negative association between prevalence of current wheezing and furry pets in the household in this last study was
thought possibly due to parental tendency to eliminate pets from the home after onset of symptoms in the family.\textsuperscript{102} Adherence to recommendations for allergen avoidance, immunotherapy, and pharmacotherapy, however, can have beneficial effects on prognosis.\textsuperscript{103,104}

CONCLUSION

The 1963 survey of twelfth grade students in Denver disclosed current prevalence of hay fever in 22% with nonseasonal rhinitis in an additional 5.6%,\textsuperscript{1} while the 1962 to 1965 survey in Tecumseh, Michigan that included physical examinations as well as interviews determined current prevalence at this age at 12% with suspected allergic rhinitis in an additional 3% and current prevalence in all ages combined at 8%.\textsuperscript{2} The prospective study of children in Tucson disclosed 42% had allergic rhinitis by 6 years of age, but this population may be overrepresentative of allergy because so many people with allergy or asthma have moved to Arizona because of its perceived salubrious climate. The NHANES II of 1976 to 1980 revealed presence of allergic rhinitis in 9% of young adults 18 to 24 years of age with chronic rhinitis in an additional 17%.\textsuperscript{6} Thus, it is not clear whether there has been a major change in prevalence of allergic rhinitis in the United States over the past 35 years.

Comparison at 16 years of age of British cohorts born in 1958 and 1970, however, indicated an increase in current prevalence of allergic rhinitis from 12% to 23.3%.\textsuperscript{9}

An immediate family history of allergic rhinitis is the best established risk factor for allergic rhinitis.\textsuperscript{5,10} Another well established risk factor is allergy, especially allergy to dust mites,\textsuperscript{6,23} nearly ubiquitous in homes in most of Western civilization, but food allergy in the first 4 years of life also is a risk factor for allergic rhinitis.\textsuperscript{23} The prophylactic effectiveness of avoidance of cow milk in infancy remains uncertain, some of the numerous studies indicating a beneficial effect,\textsuperscript{32–35} while others do not.\textsuperscript{5,23} There is some evidence that automobile or diesel exhaust fumes may enhance allergic sensitization, increasing prevalence of allergic rhinitis and asthma.\textsuperscript{18–21} Negative associations between allergic rhinitis or asthma and birth order or family size have suggested a possible protective effect of respiratory infections in early childhood or infancy.\textsuperscript{9,15,16}

The prognosis for allergic rhinitis is not good, with 10-year remission rates approximating 10% to 20%.\textsuperscript{5,39,40}

The 1963 Denver survey of eighth and twelfth grade students indicated current prevalence of asthma was approximately 3%\textsuperscript{2} while prevalence then in Tecumseh, Michigan at 10 to 15 years of age was 6% among boys with an additional 1.9% with suspected asthma and 3.7% among girls with suspected asthma in 1.1%.\textsuperscript{2} Annual National Health Interview Surveys have disclosed increases in prevalence of asthma from 3.1% in 1980 to 5.4% in 1994 (all ages combined) with increases at 5 to 14 years of age from 4.3% to 7.4%.\textsuperscript{41} National surveys of self-reported asthma may underestimate prevalence. Current prevalence has been much higher among impoverished inner city children, and undiagnosed asthma may have been nearly as frequent as physician-diagnosed asthma with combined total prevalences of 26% in Detroit and 27% in San Diego.\textsuperscript{36,47}

Increases in prevalence of asthma have been reported from many other countries, including Australia, where cumulative prevalence in one community at 8 to 10 years of age in 1992 was 37.7%, an increase from 9.1% 10 years earlier.\textsuperscript{55}

A parental history of asthma is the best recognized risk factor for asthma.\textsuperscript{61–64} Another risk factor for asthma is allergy, especially allergy to dust mites, cat, cockroach, and Alternaria. Sensitization depends upon exposure, and with sufficient exposure other fungi, dog allergen, and pollens can increase risk. Systematic reviews of effects of environmental tobacco smoke have identified parental smoking as a significant risk factor for acute lower respiratory tract illness during the first 3 years of life, and passive smoking can trigger symptoms in patients with asthma, but available data overall do not indicate passive smoking to be a risk factor for allergic sensitization or development of allergic rhinitis or asthma.\textsuperscript{85,87,88} Other risk factors include young maternal age at the time of birth, low birth weight, relatively small home, residence in a central city, single-parent household, limited maternal education, extreme poverty, and race (black or Hispanic).\textsuperscript{95} Adjustment for some of these risk factors reduces risk attributable to race or poverty, however.\textsuperscript{95}

Of children with wheezing during their first seven years, at least 25% are likely to have current wheezing at 33 to 35 years of age; those with the most frequent and most severe symptoms in childhood are even more likely to be symptomatic as adults.\textsuperscript{98,99} Active smoking is a strong risk factor for onset of asthma as an adult.\textsuperscript{98}

Why there have been increases in prevalence of asthma and in some countries allergic rhinitis is unknown. Interesting hypotheses include loss of a protective effect of respiratory infection in early childhood because of improved sanitation and immunization and increased allergenic exposure due to changes in life style. Whatever the explanation, avoidance of recognized allergens and appropriate treatment can minimize the impact of allergic rhinitis and asthma.

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All correspondence should be addressed to:
R. Michael Sly, MD
Children’s National Medical Center
Department of Allergy, Immunology & Pulmonary Medicine
111 Michigan Avenue, NW
Washington, DC 20010-2970

CME Examination
Identification No 009-003

CME Test Questions

1. Percent of people in a population with a certain condition within the previous year defines
   a. Incidence.
   b. Current prevalence.
   c. Cumulative prevalence.
   d. Cumulative incidence.
   e. Relative prevalence.

2. Surveys in Colorado and Michigan in 1962 to 1965 disclosed prevalence of seasonal and chronic rhinitis combined that
   a. Was much higher than in national surveys 15 to 20 years later.
   b. Was much lower than in national surveys 15 to 20 years later.
   c. Was similar to that in national surveys 15 to 20 years later.
d. Increased progressively with age.
e. Decreased progressively with age.

3. A national survey in 1993 indicated prevalence of self-reported allergic rhinitis was highest in
a. The East North Central Region.
b. The West North Central Region.
c. The South.
d. The Mountain Region.
e. The East.

4. The 1962 to 1965 survey of prevalence of allergic rhinitis and asthma in Tecumseh, Michigan, utilized criteria for diagnosis
a. Less rigorous than those of most subsequent studies.
b. More rigorous than those of most subsequent studies.
c. Similar to those of most subsequent studies.
d. Much broader than those of most subsequent studies.
e. That included at least one positive skin test to allergens.

5. Prevalence of seasonal and chronic rhinitis at 18 to 24 years of age in the United States probably is
a. Less than 5%.
b. 5% to 10%.
c. 15% to 25%.
d. 40% to 50%.
e. More than 50%.

6. Prospective study of children in Tucson disclosed physician-diagnosed allergic rhinitis by 6 years of age in
a. Less than 5%.
b. 5% to 10%.
c. 15% to 25%.
d. More than 40%.
e. More than 50%.

7. Prospective study of children in Tucson disclosed physician-diagnosed allergic rhinitis by 12 months of age in
a. Less than 5%.
b. 5% to 10%.
c. 15% to 25%.
d. More than 40%.
e. More than 50%.

8. In 1976 to 1980 a representative national survey disclosed prevalence of chronic rhinitis at 6 to 24 years of age, after adjustment for
age, sex, smoking, region, and other reactions, increased significantly with positive skin tests to
a. Dust mites.
b. Alternaria.
c. Cat.
d. Dog.
e. Cockroach.

9. The International Study of Asthma and Allergies in Childhood (ISAAC) indicated variations in prevalence of self-reported rhinoconjunctivitis at 13 to 14 years of age from
a. 1% to 5%.
b. 1% to 10%.
c. 1% to 40%.
d. 10% to 25%.
e. 10% to 50%.

10. The best established risk factor for allergic rhinitis is
a. Parental allergic rhinitis.
b. Parental asthma.
c. Parental eczema.
d. Maternal eczema.
e. Paternal eczema.

11. Systematic review of published studies of possible effects of passive smoking has indicated a significant association with
a. Allergic rhinitis.
b. Asthma.
c. Eczema.
d. Lower respiratory illness.
e. Positive allergy prick tests.

12. Allergic rhinitis in children resolves within 10 years in
a. Fewer than 10%.
b. 10% to 20%.
c. 25% to 35%.
d. 40% to 50%.
e. More than 50%.

13. Surveys in Colorado and Michigan in 1962 to 1965 disclosed prevalence of asthma that
a. Was much higher than in national surveys 20 to 30 years later.
b. Was much less than in national surveys 20 to 30 years later.
c. Was similar to those in national surveys 20 to 30 years later.
d. Increased progressively with age.
e. Decreased progressively with age.

14. Annual National Health Interview Surveys from 1980 to 1994 have indicated prevalence of self-reported asthma has
a. Increased most at less than 4 years of age.
b. Increased most at 5 to 14 years of age.
c. Increased most at 15 to 24 years of age.
d. Increased most at 35 to 49 years of age.
e. Increased most at more than 50 years of age.

15. Surveys of inner city children in Detroit and San Diego have disclosed current asthma or symptoms of asthma in
a. Fewer than 5%.
b. 5% to 10%.
c. 10% to 20%.
d. 20% to 30%.
e. 30% to 40%.

16. The International Study of Asthma and Allergies in Childhood (ISAAC) indicated variations in prevalence of symptoms of asthma from
a. 1% to 5%.
b. 1% to 10%.
c. 1% to 40%.
d. 10% to 25%.
e. 10% to 50%.

17. Countries with highest prevalences of current symptoms of asthma at 13 to 14 years of age as reported from ISAAC include
a. China and India.
b. New Zealand and Greece.
c. Ireland and Taiwan.
d. United Kingdom and Australia.
e. Brazil and Indonesia.

18. Data from Norwegian twins indicate risk of asthma is
a. Twice as great in identical as fraternal twins.
b. Twice as great in fraternal as identical twins.
c. Four times as great in identical as fraternal twins.
d. Six times as great in identical as fraternal twins.
e. More than seven times as great in identical as fraternal twins.
19. The allergenic source identified most often as a risk factor for asthma has been
   a. Alternaria.
   b. Cat.
   c. Dog.
   d. Cockroach.
   e. Dust mites.

20. Follow-up of children with current asthma or wheezing at 7 years of age has disclosed what percent with wheezing during the previous year 25 to 30 years later?
   a. Fewer than 10%.
   b. 10% to 20%.
   c. 20% to 30%.
   d. 40% to 50%.
   e. More than 50%.

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1. b
2. d
3. b
4. e
5. e
6. e
7. c
8. c
9. e
10. c
11. c
12. e
13. a
14. a
15. d
16. e
17. d
18. d
19. b
20. c