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Observations on emerging patterns of asthma in our society

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Epidemiologic studies of temporal and geographic variation in asthma morbidity have identified asthma as an important public health concern. Knowledge gained from these studies has resulted in intense focus on this condition by agencies such as the National Institutes of Health and the World Health Organization. In this report, studies of recent asthma trends and patterns are explored. These studies show increases in US prevalence through 1994. Data on measures of morbidity show complex longitudinal patterns but are notable for large differences in emergency department services and hospitalizations by age and race. Very recent trends for US asthma mortality suggest widening of an existing racial gap. Limited comparisons are possible between these US trends and international trends but do suggest that US increases in prevalence and mortality rates may reflect world-wide patterns. Also, within the US, it is clear that geographic variation exists in asthma prevalence, morbidity, and mortality rates. Changes in certain environmental risk factors and exposures may contribute to recent trends, but little information is available relating specific risk factors to either longitudinal asthma trends, geographic variability, or high-risk populations. (*J Allergy Clin Immunol* 1999;104:S1-9.)

Key words: Asthma, epidemiology, mortality, hospitalization, prevalence, geographic variations

There seems to be an ever increasing interest in asthma. The National Asthma Education and Prevention Program (NAEPP) of the National Institutes of Health (NIH), now in its ninth year, is continually exploring ways to educate the nation about the burden of asthma and methods for effective disease control. In many US cities, asthma morbidity has become the target of community coalitions. Other countries have similar asthma education efforts

Abbreviations used

CDCP:	Centers for Disease Control and Prevention
ECRHS:	European Community Respiratory Health Survey
ED:	Emergency Department
ETS:	Environmental tobacco smoke
ISAAC:	International Study of Asthma and Allergies in Childhood
NAEPP:	National Asthma Education and Prevention Program
NCHS:	National Center for Health Statistics
NHIS:	National Health Interview Survey
NHANES:	National Health and Nutrition Examination Survey
NHAMCS:	National Hospital Ambulatory Medical Care Survey
NHDS:	National Hospital Discharge Survey
NIH:	National Institutes of Health
PM-10:	Particles less than 10 μ m

underway, some predating and others newer than the NAEPP activities. Most recently, the NIH joined forces with the World Health Organization to find ways to lessen the global impact of asthma.

With all these efforts, it is easy to lose sight of the basic epidemiologic patterns underlying much of the recent interest in asthma. What are the trends in asthma morbidity in the United States? Are the patterns of asthma morbidity in the United States similar to international trends? What is the geographic variation in asthma morbidity, and specifically, is there a disproportionate burden within urban environments? What are some of the factors associated with the emerging patterns of asthma morbidity? Last, what can be done to reduce asthma morbidity?

The continual search for answers to questions such as these help to maintain the focus on asthma prevention and reduction of asthma morbidity. The purpose of this report is to review the recent epidemiologic information in an attempt to answer the above questions. While a comprehensive review of any of these questions is beyond the scope of a single report, this review will present some of the key recent findings in this area.

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TABLE I. Prevalence of asthma by selected demographic characteristics, United States, 1990-92.

	No. per 100 persons
All ages	4.62
Age group	
Under 19	6.12
18-44	4.12
45-64	4.15
65 plus	3.82
Sex	
Male	
All ages	4.41
Under 18	7.23
Female	
All ages	4.81
Under 18	4.97
Race	
White	4.57
Black	5.33
Geographic region	
Northeast	4.54
Midwest	4.59
South	4.42
West	5.02
Income	
<\$10,000	6.61
\$10,000-19,999	4.48
\$20,000-34,999	4.09
≥\$35,000	4.56

(From Collins JG. Prevalence of selected chronic conditions: United States 1990-1992, National Center for Health Statistics. Vital Health Statistics 1997;10:194)

WHAT ARE THE TRENDS IN ASTHMA MORBIDITY IN THE UNITED STATES?

The major measures of asthma morbidity currently under surveillance in the US include prevalence, emergency department (ED) visits, hospitalizations, and mortality. In addition, data on quality of life and economic impact are also becoming available.

Prevalence

Most of what is known about the current estimates and trends in asthma prevalence is derived from analyses of the surveillance surveys conducted by the National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention (CDCP). The NCHS conducts two surveys that provide data on asthma prevalence, the National Health Interview Survey (NHIS) and the National Health and Nutrition Examination Survey (NHANES).

The NHIS is an annual nationwide survey of households. Each week, personnel from the US Bureau of the Census interview a probability sample of the civilian, noninstitutionalized, US population. During the course of these interviews, information is obtained about health and other characteristics of each member of the household.¹ More than 100,000 US households are interviewed annually, and a subsample of those households are questioned about asthma. From this, the period prevalence of

asthma (self-reported asthma in the past 12 months) can be estimated. The data are used as the basis for many of the recent reports of increases in US asthma prevalence.

As seen in Table I, during 1990 to 1992, the prevalence of asthma in the United States was 4.6%, affecting an estimated 11.5 million persons.² Asthma prevalence was higher for persons under 18 years of age (6.1%) than for older age groups and was also slightly higher for females than males (4.8% vs 4.4%, respectively). However, one of the highest prevalence rates occurred in young males less than 18 years old (7.2%). The rate for blacks (5.3%) was higher than that of whites (4.6%), and the rate was higher in the western region of the United States (5.0%) than in the northeast, midwest, and south (4.5%, 4.6%, and 4.4%, respectively). Asthma prevalence rates also appeared to be higher for persons living in households with lower family income.

Recently, the CDCP reviewed 15-year trends in asthma prevalence. As seen in Fig 1, the NHIS data from 1980 to 1994 showed a 75% increase in asthma prevalence for all ages. This increase was significant by age, sex, and race and appeared to be increasing at a faster rate for children and young adults (less than 34 years). The most notable increase occurred in the 0 to 4 years age group (160%).³

NHANES includes both interviews and physical examinations of a random sample of the US civilian population.⁴ NHANES I was conducted in 1971 to 1974 and NHANES II in 1976 to 1980.⁵ A third NHANES survey was recently completed; however, data from this survey are not yet available to the public. Estimates of asthma prevalence from the NHANES surveys differ from that of NHIS, probably because of variances in the phrasing of the specific questions related to asthma prevalence. However, similar to the NHIS data, NHANES data suggest there was an increase in asthma prevalence for children ages 6 to 11 years during the 1970s. Because of differences in survey methodology, it is not possible to examine trends for the other age groups.⁶ When available, data from NHANES III will provide additional insights to more recent US trends.

ED visits and hospitalizations

ED visits and hospitalizations represent another dimension of asthma morbidity. To a large extent, both measures represent the acute morbidity associated with an asthma exacerbation. However, these measures can only be considered proxies for severity because many persons manage acute exacerbation without the need for either ED or hospital care. Also, EDs often provide routine (nonurgent) care for individuals who are unable to afford access to a regular physician.

The NCHS conducts ongoing surveillance of both ED visits and hospitalizations for asthma. Information on emergency care is obtained annually through the National Hospital Ambulatory Medical Care Survey (NHAMCS), which began in 1992.⁷ This survey is conducted on a probability sample of EDs of non-Federal, short-stay hospitals throughout the United States. Each participat-

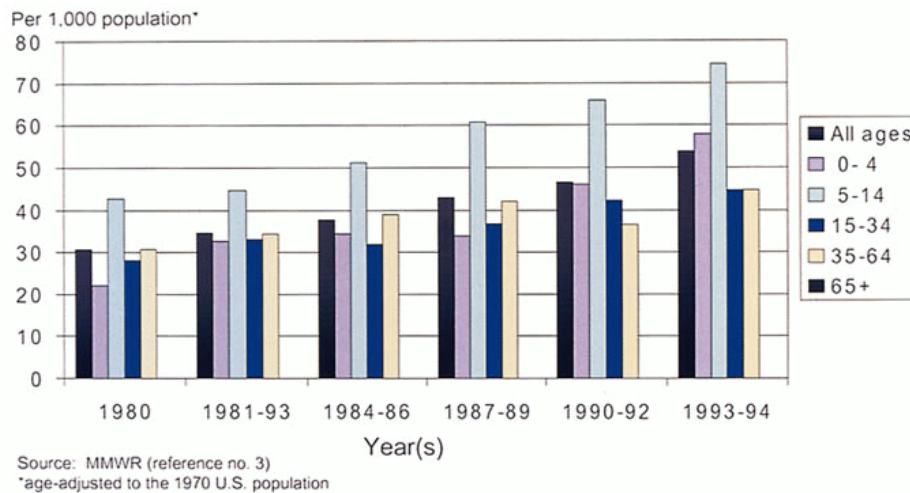


FIG 1. Trends in estimated average annual rate of self-reported asthma during preceding 12 months by age group, United States, 1980 to 1993 and 1994.

ing ED is asked to provide information on a sample of patient visits.

In 1995, there were an estimated 1.9 million ED visits for asthma, representing 1.9% of all ED visits in the United States.⁸ The rate of ED visits for asthma was 70.7 per 10,000 population.³ This rate was higher for younger children (ages 0 to 4 years old) than for older age groups, at 120.7 per 10,000. The rate was also higher for females than for males, 82.3 versus 57.8 per 10,000 population, respectively. ED visit rates for asthma demonstrated a large difference by race, with the rate for blacks at 228.9 per 10,000 population, 4.7 times higher than the rate for whites. However, although the 1995 data shows some interesting patterns, there are no clear trends in US asthma ED visit rates when the data are examined longitudinally (1992 to 1995).

The NCHS has been monitoring hospitalizations since 1963. The National Hospital Discharge Survey (NHDS) provides annual estimates of the number of visits to non-Federal, short-stay hospitals. Similar to the NHAMCS, data from this survey are obtained from a sample of US hospitals. In turn, each participating hospital provides a systematic random sample of discharge information.

In 1996, there were an estimated 474,000 hospital discharges with asthma as the first-listed diagnosis, leading to a rate of 18.0 discharges per 10,000 population and equating to 1.7 million bed days. Forty-one percent of these discharges were for children under the age of 15 years.⁹ Hospitalization rates were highest for children age 0 to 4 years and were 3.5 times higher for the black population as compared with whites.³

Overall, US hospitalization rates for asthma did not change significantly during the periods from 1979 to 1980 and 1993 to 1994 (17.6 vs 18.1 per 10,000 population, respectively).³ However, for two groups, whites and persons 65 years and older, hospitalization rates for asthma appear to demonstrate a decreasing trend. Yet, this

trend must be viewed in light of overall decreasing trends in hospitalization rates for all conditions.

Mortality rates

The NCHS has been monitoring US vital records since the late 1920s. Unlike the other surveys of population samples, the NCHS vital records system monitors all deaths in the United States.

Although an infrequent event, asthma deaths in the United States have been well studied.¹⁰⁻¹³ One of the notable issues has been the high rate of diagnostic misclassification that occurs for persons in older age groups. A high proportion of older persons with asthma recorded as the underlying cause of death have been found at autopsy to have nonasthma causes of death.^{14,15} Due to the higher likelihood of misclassification, much of the literature relating to asthma mortality targets the age group 5 to 34 years old.

In 1995, there were 5,637 deaths in the United States in which asthma was listed as the underlying cause, and 11.6% of these deaths were in the age group 5 to 34 years.¹⁰ Asthma mortality rates in this younger age group were higher for males than females (0.61 vs 0.52 per 100,000 population), and the rate was disproportionately higher for blacks than for whites (1.67 vs 0.38 deaths per 100,000 population).

In addition to the data from US vital records, there has been at least one study examining nearly 50 years of US asthma mortality rates for persons 5 to 34 years old.¹⁰ This study indicates that in the United States, asthma mortality rates remained relatively unchanged from the 1950s through the 1960s. During the 1970s there was a significant decline in mortality rates, followed by a significant increase in rates in the 1980s. During the 1990s asthma mortality rates have remained relatively stable except for selected subpopulations. However, as seen in Fig 2, blacks

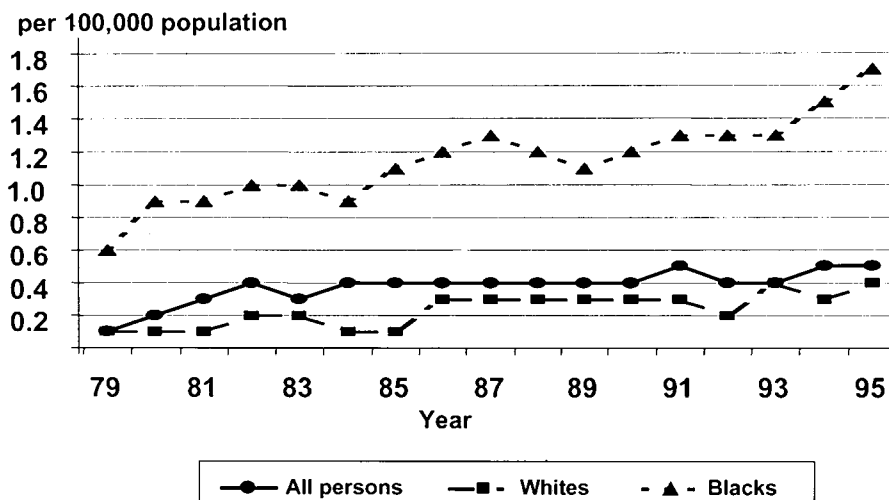


FIG 2. Trends in US asthma mortality rates as underlying cause of death, 1970 to 1995, in persons 5 to 34 years of age by race (age-adjusted to 1970 population).

have continually demonstrated higher asthma mortality rates than whites. Most troubling is that in the past 2 years, the asthma mortality rate for blacks is increasing at an even greater rate than previous years.

Social burden

Recently, attention has been drawn to the many dimensions of the social burden of asthma that go beyond simple measures of asthma prevalence, use of EDs, hospitalization, and mortality rates. In particular, information is beginning to emerge on the health status and quality of life of persons with asthma as well as the economic impact of asthma. Most of what is known about health status and quality of life is derived from the NHIS survey. During the period of 1990 to 1992, the NHIS reported 133.8 million days of restricted activity as the result of asthma in the United States, averaging 11.7 days per person.²

The US economic burden of asthma has also been characterized.¹⁷ In 1990, asthma costs were estimated at 6.2 billion dollars. Nearly 59% of these costs were attributed to direct medical expenditures and 43.4% to indirect costs.

Although studies of the past several years have broadened our view of the social impact of asthma on our society, there have been no US studies of the temporal trends of this impact.

ARE THE PATTERNS OF ASTHMA MORBIDITY IN THE UNITED STATES SIMILAR TO INTERNATIONAL TRENDS?

Direct comparisons of the trends in asthma morbidity between the United States and other countries are very limited. Studies of the trends in asthma prevalence differ in methodology both between countries and even within countries. Very few countries conduct nationwide surveillance of asthma morbidity as measured by emergency care or hospitalizations. However, high quality vital

records systems have been in operation in many countries for decades. Therefore, most of the international comparisons in asthma morbidity are derived from studies of asthma mortality rates.¹⁸⁻²⁰

Although there are limitations associated with the differing methodologies among the many international asthma studies, there are still some observations that can be made about international trends in asthma prevalence. One recent review article examined 23 studies of changes in asthma prevalence over time (see Table II).²¹ Each of the 23 studies used slightly different methods for population sampling, inclusion criteria, and asthma assessment, and most examined different time periods. However, respective of all these differences, each of the studies used internally consistent methods and so a general pattern of asthma prevalence can be inferred. Specifically, each of these studies demonstrated an increase in asthma prevalence over time. However, very little can be gleaned about the duration, magnitude, or full global extent of this apparent international increase in asthma prevalence.

As noted previously, there is very little published information on asthma emergency care or hospitalization rates for most countries. A study from England suggests asthma hospitalizations, at least for younger children, have been increasing steadily since the 1970s.²² In Scotland, ED visits for asthma are reported to have increased during 1981 to 1993.²³ Finland reported increased hospital admissions for children with asthma during the 15-year period of 1972 to 1986. However, this increase was only seen for younger children less than 5 years of age.²⁴ Canada reported their national rate of hospital admissions for asthma increased greatly, though changes in the rate varied by province.²⁵ Given the small number of studies to date, each examining different time periods, it is difficult to assess any common international trend for these aspects of asthma morbidity.

Unlike morbidity, data on asthma mortality rates are

TABLE II. Changes in asthma prevalence in children and young adults

Country	Period	Asthma prevalence		Reference
		1st study	2nd study	
Australia	1964-1990	19.1%	46.0%	Robertson et al (1991)
	1982-1992	12.9%	19.3%	Peat et al (1994)
Canada	1980-1983	3.8%	6.5%	Infante-Rivard et al (1987)
England	1956-1975	1.8%	6.3%	Morrison Smith (1976)
	1966-1990	18.3%	21.8%	Whincup et al (1993)
	1973-1986	2.4%	3.6%	Burney et al (1990)
Finland	1961-1986	0.1%	1.8%	Haahtela et al (1990)
France	1968-1982	3.3%	5.4%	Perdizet et al (1987)
Israel	1986-1990	7.9%	9.6%	Auerbach et al (1993)
Italy	1983-1993	2.9%	4.4%	Ciprandi et al (1996)
Japan	1982-1992	3.3%	4.6%	Nishima (1993)
Netherlands	1977-1992	19%	31%	Tirimanna et al (1996)
New Zealand	1969-1982	7.1%	13.5%	Mitchell (1983)
	1975-1989	26.2%	34.0%	Shaw et al (1990)
	1981-1990	22.8%	30.8%	Kljakovic (1991)
Papua New Guinea	1973-1984	0.0%	0.6%	Dowse et al (1985)
Scotland	1964-1989	10.4%	19.8%	Ninan and Russell (1992)
Sweden	1971-1981	1.9%	2.8%	Alberg (1988)
Tahiti	1979-1984	11.5%	14.3%	Liard et al (1988)
Taiwan	1974-1985	1.3%	5.1%	Hsieh et al (1988)
United States	1971-1976	4.8%	7.6%	Gergen et al (1988)
	1981-1988	3.1%	4.3%	Weitzman et al (1992)
Wales	1973-1988	4.0%	9.0%	Burr et al (1989)

(From Pearce N, Beasley R, Burgess C, Crane J. Measuring asthma prevalence. In: Asthma epidemiology: principles and methods. New York: Oxford University Press; 1998. p.77-80. Copyright © 1998 by Oxford University Press, Inc. Used by permission of Oxford University Press, Inc.)

available for many countries.¹⁹ Much of the focus on the international trends in asthma mortality rates relates to an apparent epidemic rise in at least seven Western countries during the 1960s. Yet, with the exception of this 1960s epidemic, there has been a small but steady worldwide increase in asthma mortality rates through the late 1980s (Table III).¹⁹ The international trends for the 1990s are less well defined.

WHAT IS THE GEOGRAPHIC VARIATION IN ASTHMA MORBIDITY, AND SPECIFICALLY, IS THERE A DISPROPORTIONATE BURDEN EXPERIENCED WITHIN URBAN ENVIRONMENTS?

Over the past several years, there has been a dramatic increase in our knowledge of the geographic variations in asthma morbidity. Most recently, the results of two important international studies have contributed to this knowledge, the European Community Respiratory Health Survey (ECRHS)²⁶ and the International Study of Asthma and Allergies in Childhood (ISAAC).²⁷

The ECRHS studied asthma prevalence among adults

TABLE III. Asthma mortality rates (deaths per 1000,000 persons) in 10 countries between the mid-1970s and mid-1980s in persons 5 to 34 years of age

Country	1975-1977	1985-1987	Percent increase
Australia	0.86	1.42	65
Canada	0.33	0.47	42
England and Wales	0.57	0.90	58
France	0.24	0.51	113
Japan	0.44	0.59	34
Singapore	0.75	0.88	17
Sweden	0.37	0.54	46
Switzerland	0.31	0.45	45
United States	0.19	0.40	111
West Germany	0.59	0.78	32

(From Beasley R, Pearce N, Crane J. International trends in asthma mortality. In: Chadwick D, Cardow G, eds. The rising trends in asthma. Ciba Foundation Symposium 206. Chichester: John Wiley & Sons Ltd; 1997. p. 140-56.)

age 20 to 44 years across 48 study centers located primarily in Western Europe.²⁸ In this study, the presence of asthma symptoms varied widely across countries and among centers within countries. Asthma prevalence was generally lower in northern, central, and southern Europe and higher in the British Isles, New Zealand, Australia, and the United States.

During the same general time period, the ISAAC study also examined asthma prevalence. However, ISAAC focused on children ages 6 to 7 and 13 to 14 years. ISAAC was conducted across 155 collaborating study centers among 56 countries. Estimates were based on 12-month prevalence data. ISAAC found a large variation in asthma prevalence in the 13- to 14-year-olds, both among countries and among centers within countries. The center with the highest prevalence showed a rate approximately 20 times greater than the rate of the center with the lowest prevalence (range 1.6% to 36.8%), with an 8-fold variation seen between the 10th and 90th percentiles (3.9% to 30.6%).

There are several studies examining the correlation between geographic location and asthma prevalence and morbidity. For children, asthma prevalence has been reported to be greater in urban areas as compared with rural areas; this same relation between urbanization and asthma is less clear in adults.²⁹ For example, one study reported a higher prevalence of asthma in urban areas for children 3 to 17 years of age,³⁰ yet another study reported the reverse for persons 12 to 94 years of age.³¹ A comparison of data from the Child Health Supplements to the NHIS in 1981 and 1988 showed equal increases in asthma prevalence in rural and urban areas.³²

Although US national survey data do not demonstrate consistent overall increases in asthma prevalence in urban versus rural areas, recent small areas studies of targeted cities have estimated the prevalence of asthma to be twice as high as the national estimates.^{33,34}

There are no US studies of geographic variation in asthma morbidity as measured by ED visits or hospital-

izations. There are, however, several state analyses that suggest large geographic variation among urban versus rural counties. For example, a study of hospitalizations in Massachusetts³⁵ found increases in preventable hospitalizations, including asthma, strongly correlated with several characteristics common to inner-city populations: low income, Medicaid enrollment, and proportion of the population who were nonwhite.

Maryland was the site of one of the most notable studies of small area geographic variations of asthma hospitalizations. This study found that for white children, there was an inverse correlation between hospital discharge rates and the percentage of families living in urban areas. This correlation was not demonstrated for non-white children. This study reported an extremely high rate of asthma hospitalizations within the Baltimore inner-city.

The Maryland study laid the groundwork for a series of other small area geographic analyses of asthma hospitalization rates in the US cities of New York,³⁶ Boston,³⁷ and Chicago.³⁸ These studies consistently demonstrated higher asthma hospitalization rates among city neighborhoods with the lowest household or family income and highest proportion of minority populations. Collectively, these studies suggest that US asthma morbidity, as measured by hospitalization rates, demonstrates high geographic variability and that some of the highest rates are found in selected urban inner-city neighborhoods.

Studies of geographic variation in asthma mortality rates have also guided the identification of high-risk subpopulations. One study of small-area variation of excess mortality of the US population 5 to 34 years of age found three large urban areas (New York City, Chicago, and Phoenix) to have consistently elevated asthma mortality rates.¹³ Separate studies of small area variations of asthma mortality rates within neighborhoods of New York City,³⁶ Chicago,³⁹ and Philadelphia⁴⁰ all demonstrated findings similar to the hospitalization studies noted above; specifically, inner-city neighborhoods of low socioeconomic status and high minority representation are at disproportionately high risk for adverse asthma outcomes.

WHAT ARE SOME OF THE FACTORS ASSOCIATED WITH THESE EMERGING PATTERNS OF ASTHMA MORBIDITY?

A detailed discussion of the epidemiologic studies that support causal relations between risk factors and temporal or geographic trends is beyond the scope of this report. However, there are several comprehensive reviews on this topic that may be of interest.^{10,19,41,42} Below is a brief discussion of some of the factors possibly contributing to the current patterns of asthma morbidity.

It has been proposed that some of the increase in asthma prevalence may be attributed to enhanced diagnostic awareness of asthma on the part of both health care providers and the general public. This would be natural, considering the US and international asthma education efforts to heighten public awareness. Yet, it is unlikely

that enhanced diagnostic recognition could contribute to any of the hospitalization or mortality trends.

Shifts in diagnostic labeling also could play a significant role, such that certain diagnoses of bronchitis are now likely to be labeled as asthma by health care providers.^{10,43} However, any shift in diagnostic labeling is likely to be contributing only a portion of the change in the expression of asthma morbidity.⁴⁴⁻⁴⁶

Changes to the risk factors associated with asthma also could explain recent trends in asthma morbidity. A number of risk factors have emerged as possible causal agents; these include early exposure, outdoor and indoor environmental changes, and changes to the medical environment.

Low birth weight may be a risk factor for asthma.⁴⁷ Over the past few decades, a growing number of low birth weight infants are surviving. From 1971 through 1982, US perinatal mortality rates decreased for infants of all birth weights, both black and white.⁴⁸ It is plausible that this trend may be associated with increases in asthma prevalence, morbidity, and mortality rates. However, with the proportionally small impact, it could not have a great deal of influence on the overall trends in asthma.

Changes in the outdoor environment may also play a role in asthma morbidity. It is possible that changes in allergen exposure could lead to increases in asthma morbidity. However, there is little evidence of any major changes in outdoor allergen load, either in the United States or internationally. The general trend in US air pollution is uniformly down,⁴⁹ and the data indicate larger particles of air pollution. Yet it is the smaller particles, less than 10 μm (PM-10), that are more important in respiratory disease. There has also been recent interest in the possible relationship between allergic respiratory disease and increases in polyaromatic hydrocarbons.^{50,51} However, this relationship is still being explored.

Indoor environmental changes also might help to explain the secular patterns in asthma morbidity. There are numerous potential indoor risk factors, including cigarette smoke, aeroallergens, viral agents, molds, and irritant gases. Studies are beginning to document the negative effect of environmental tobacco smoke (ETS) on the respiratory health of younger children with asthma.^{52,53} However, although the role of smoke, both active and ETS, is becoming more clearly linked to asthma morbidity, its role as a risk factor for incident asthma is less clear. The overall prevalence of cigarette smoking in the US adult population decreased from 42% to 25% between 1965 and 1993.^{54,55} Most people begin smoking as adolescents, and the prevalence of cigarette smoking among adolescents has, to a large extent, leveled off in recent years.^{54,56} Although smoking is an important risk factor to consider in relation to recent trends in asthma morbidity, there is not enough current data to declare smoking as the driving force behind the observed increase in asthma morbidity.

Allergens are perhaps the most important and accepted risk factor for asthma morbidity. Unfortunately, there are no available population-based data on trends associ-

ated with exposure to the most common asthma-related allergens. Viral infections are also well known to be precipitating factors of asthma attacks.⁵⁷ Yet, similar to allergens, there are no available data on trends of exposure to these agents.

The overall effect of indoor environmental factors (eg, allergens, smoke, infectious agents, or irritant gases) is mediated by building construction. Housing conditions in the United States have changed over the past few decades, and air exchange, heating, and building materials have all been affected by these changes. It is important to consider the home, work, and school environment as key factors relating to the recent trends; yet there is little data to support a direct relation to asthma morbidity at this time.

The medical environment may also be contributing to the recent trends in asthma morbidity. There have been remarkable changes in asthma pharmacotherapy during the past few decades. Some of the most dramatic changes include increased prescriptions for inhaled adrenergic agents beginning in the late 1970s and increases in inhaled corticosteroid prescriptions in the early 1990s.^{58,59} At the same time, there are increasing numbers of persons who are uninsured or underinsured for health care. It is unclear how issues relating to access and quality of care may be contributing to the trends in asthma morbidity and mortality rates.

Emerging biomedical research is ever increasing our knowledge of the relation between environmental exposures and the immune response. A better understanding of this relation may lead to new hypotheses that could eventually explain some of the trends in asthma morbidity. For example, one newly emerging theory poses that reduction in childhood infections is altering the mucosal immune response away from a T_{H1} -like to a T_{H2} -like response with subsequent increased development of allergic phenotypes.⁶⁰ Another theory poses that decreases in use of pediatric aspirin have led to increases in T_{H2} -type immune responses, thereby creating an environment favorable to the development of asthma or allergies.⁶¹ Also, new knowledge of different polymorphisms of the β_2 -adrenergic receptor open the possibility that certain genotypic subpopulations with asthma may have a differing response to one of the main pharmacotherapeutic agents for asthma control, thereby leading to differing outcomes.⁶² Unfortunately, these theories are still in the stages of research and so cannot be linked with certainty to the recent trends in asthma morbidity.

WHAT CAN BE DONE TO REDUCE ASTHMA MORBIDITY?

The rapidly growing body of descriptive epidemiologic studies of asthma is beginning to define important patterns of asthma morbidity. Principal among these findings is that current US national surveillance suggests that asthma prevalence is increasing. This increase also appears to be occurring in other countries as well. However, there is limited international data on trends in asthma morbidity. Yet,

with the exception of certain subpopulations who appear to be at high risk, the trends in US asthma morbidity, as measured by visits to the ED and hospitalization rates, do not parallel the increases seen in asthma prevalence. Data from US studies strongly suggest that younger children, African Americans, and persons of lower socioeconomic status are at disproportionately higher risk for asthma and its untoward clinical outcomes.

The literature also suggests that there is large geographic variation in asthma prevalence, morbidity, and mortality rates. These studies, at least in the United States, have led to the knowledge that populations living within economically deprived areas of the inner-city are at highest risk for hospitalization and death.

The conflicting time periods and differing methodologies of the asthma epidemiology studies to date do not allow for any direct comparisons and make it difficult to discern the national and international trends in asthma prevalence and morbidity. In addition, there are many plausible but as yet unproven theories as to the specific risk factors underlying these trends. So the question remains as to what could or should be done to reverse the harmful epidemiologic trends.

Currently, there is no clear answer to this question. However, in devising new strategies to address this important public health concern, it will be essential to focus on new research as well as current interventions, especially for the populations at highest risk.

It has been suggested that "in many ways, the epidemiology of asthma is in a situation similar to that of cancer epidemiology or cardiovascular disease epidemiology before the major advances in understanding of the causes of these diseases in the 1960s."²¹ If this is true, there is much work to be done in developing and implementing new hypotheses generating epidemiologic studies, targeting plausible risk factors for asthma and its outcomes.

Perhaps the first step in addressing this issue will be an increased commitment to publicly funded research in this area. Modeled on the strong support of the National Cancer Institute's epidemiologic effort, and the National Heart, Lung and Blood Institute's earlier efforts in cardiovascular disease, we may, in time, clearly identify the risk factors underlying the emerging patterns of asthma morbidity.

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