Chapter 1
Considerations Regarding the Epidemiology and Public Health Burden of Asthma

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Epidemiologic Studies: An Introduction

Epidemiology has been defined as the study of the distribution and determinants of diseases and health. Commonly used epidemiological study designs are ecological studies, cross-sectional studies, case-control studies, prospective studies, and randomized trials. In an ecological study, levels of potential or actual risk factors are correlated with levels of disease across distinct geographically defined populations either among countries or within countries. In a cross-sectional study, a sample of participants is selected and subsequently those with a particular condition are compared with those who do not have that condition. Such studies provide solid information about the prevalence of a condition and the attendant risk factors. However, cross-sectional studies provide weaker evidence for potential associations between possible risk factors and outcomes than case-control or prospective studies. In a case-control study, people with a condition are selected and a separate control group is selected, and then the two groups are compared. These studies are usually performed to look for associations between potential risk factors and disease. Furthermore, case-control studies are a practical method to study associations for diseases that are relatively rare. In a prospective study (cohort study, panel study, longitudinal study), a sample of participants is selected and they are followed forward in time. These studies provide the most compelling evidence for possible causal relationships between potential risk factors and diseases, in part because the exposure of interest occurs prior to the outcome. Cross-sectional studies, case-control studies, and prospective studies are commonly referred to as observational studies. Each of these study designs is subject to various biases. Thus, the results from studies using these various study designs must be interpreted in the context of potential bias. In a randomized clinical trial, participants with a condition are selected, and they are then randomly assigned to one or more intervention groups or a control group. In a randomized community trial, communities are selected and randomly allocated to receiving an intervention or no or lower-level intervention. Such trials are generally considered to provide the most rigorous evidence supporting the causal relationship between a risk factor and disease or the usefulness of a specific treatment.

Public Health Burden of Asthma

A variety of measures can be used to assess the public health burden of asthma (Sennhauser et al. 2005; Bousquet et al. 2005). Prevalence is the proportion of people with asthma in a population, and incidence rate is a measure of the instantaneous force of asthma occurrence. Prevalence may be delineated into point prevalence (the proportion of people with asthma at a given point in time) and period prevalence (the proportion of people with asthma during a specified period of time such as the past 12 months). Incidence rate refers to the new onset of asthma during a specified period of time (number of new cases per unit of person-time), whereas cumulative incidence refers to the proportion of people initially free of disease who subsequently develop disease over a certain time span. Mortality

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rates provide an idea of how deadly the condition is and also an estimate of premature mortality through a calculation of years of productive life lost. Examining the number of physician office visits, emergency room visits, and hospitalizations yields important insights into the use of and need for medical resources and whether the capacity of the medical care sector is adequate to meet the need. Estimates of the direct and indirect costs of the disease provide critical insights into the dimensions of health care resources that are needed to combat this condition. Inherently tied to estimating indirect costs are the number of lost school days and lost workdays attributable to asthma. Measuring disability-adjusted life years and health-related quality of life of people with asthma provides another dimension of the burden of asthma.

Defining Asthma

Critical to the conduct of epidemiological studies and to examining the various facets of asthma is the availability of a case definition for asthma. In the Second Expert Panel Report of the Guidelines for the Diagnosis and Management of Asthma, asthma was defined as "a chronic inflammatory disorder of the airways in which many cells and cellular elements play a role, in particular, mast cells, eosinophils, T lymphocytes, neutrophils, and epithelial cells. In susceptible individuals, this inflammation causes recurrent episodes of wheezing, breathlessness, chest tightness, and cough, particularly at night and in the early morning. These episodes are usually associated with widespread but variable airflow obstruction that is often reversible either spontaneously or with treatment. The inflammation also causes an associated increase in the existing bronchial hyperresponsiveness to a variety of stimuli" (National Asthma Education and Prevention Program 1997). This definition is rooted in physiology and clinical considerations. For epidemiological purposes, however, a workable definition for use in often large-scale studies is a sine qua non.

Several approaches to defining asthma for epidemiologic use or developing case definitions have been taken (Table 1.1). The use of questionnaires is perhaps the most common approach. A single question or a series of questions is used to identify people with asthma. Examples from several large US surveys have been summarized elsewhere (Centers for Disease Control and Prevention 2009). Although this approach is conceptually attractive and is inexpensive, the validity and reliability of identifying people with asthma in this way need to be established. The simplicity of this approach can also lead to the creation of numerous such instruments that differ in minor or major ways, thus possibly compromising comparisons of study results. Consequently, attempts have been made to standardize asthma questionnaires to facilitate comparisons of the prevalence of asthma among populations as was done in the European Community Respiratory Health Survey (ECRHS 2007) and International Study of Asthma and Allergies in Childhood (ISAAC 1993). The development of such questionnaires requires a process of testing the validity and reliability of the questions (Venables et al. 1993; Jenkins et al. 1996; Galobardes et al. 1998; Sole et al. 1998; Wolf et al. 1999; Kilpelainen et al. 2001a; Aroni et al. 2004; Redline et al. 2004). This process may have to be repeated for special populations such as health-care workers (Delclos et al. 2006).

Table 1.1 Methods for determining asthma in epidemiological studies

Questionnaires
Diaries
Medical records
Administrative data bases
Pharmacy
Health maintenance organizations
Outpatient visits
Emergency room
Hospitalizations
Vital statistics
Provocation tests (bronchial hyperresponsiveness)
Methacholine challenge test
Histamine challenge
Adenosine 5′-monophosphate
Exercise challenge test
Cold air challenge
Hypertonic saline
Lung function tests
Spirometry
Peak expiratory flow rate variability
Exhaled nitric oxide
Eosinophilia
Blood sputum eosinophils

Asthma from Medical Records

Using medical records to identify people with asthma is another method of case ascertainment

(Wamboldt et al. 2002). The use of this technique depends heavily on the diagnosis made by clinicians. Although national or professional guidelines for diagnosing asthma have been developed, the degree to which clinicians adhere to these guidelines is not always clear. Thus, differences in diagnostic practices may occur among clinicians. In a sample of 182 children, the reliability and validity of coding asthma outcomes were good (Wamboldt et al. 2002).

Asthma from Administrative Databases

Large administrative databases are used for a variety of purposes including estimating the prevalence of disease, examining the use of medical resources (hospitalizations, physician-office visits, emergency room visits), performing pharmacoepidemiological studies, examining treatment patterns, following the prognosis of a disease, and studying compliance with guidelines (Blais et al. 2006). In the United States, examples include the National Hospital Discharge System, Nationwide Inpatient Sample, the National Ambulatory Care Medical Survey, National Hospital Ambulatory Medical Care Survey, National Disease and Therapeutic Index, Medicare, Medicaid, and health maintenance organization databases. For many of these databases, conditions are often coded using the International Classification of Diseases. In addition, large pharmacy databases can be used to identify people who use asthma medications (Allen-Ramey et al. 2006).

Bronchial Hyperreactivity Testing

Determining the presence of asthma using questionnaires was not considered a rigorous method; measuring airway hyperresponsiveness was considered a more physiologic approach. However, several considerations limit the use of this method. It is time-consuming, resource-intensive, and carries a small risk for an adverse event. Some proportion of people with asthma do not have airway hyperresponsiveness as determined by bronchial hyperreactivity testing. Thus, this approach may underestimate people with asthma, especially those with mild asthma. For example, approximately 30% of children with asthma may not have bronchial hyperreactivity, whereas approximately 15% of children who have never wheezed may have a positive bronchial hyperreactivity test (Phelan 1994).

Nevertheless, bronchial hyperreactivity is often used as a "hard measure" of asthma. Testing for bronchial hyperreactivity may involve the use of metacholine, histamine, adenosine, cold air, hypertonic saline solution, and exercise as triggers (de Meer et al. 2004).

Furthermore, different protocols exist for various stimulants that could yield somewhat different findings in studies. The relative merit of these protocols is still being investigated (Haby et al. 1995).

Death Certificates

Because deaths from asthma are a relatively rare occurrence, the use of death certificates for case-definitions of asthma is usually confined to studies of mortality trends. Diagnostic practices for asthma may show geographical and temporal variation, and it is, therefore, helpful to understand the validity of death certificates when comparing study results (Subcommittee of the BTA Research Committee 1984; Sears et al. 1986; Campbell et al. 1992; Jenkins et al. 1992; Hunt et al. 1993; Wright et al. 1994; Guite and Burney 1996; Sidenius et al. 2000).

Exhaled Nitric Oxide

The recognition that inflammation of the airways is an important component of asthma provides a rationale to attempt to diagnose asthma by measuring the underlying inflammation. One such test is the measurement of exhaled nitric oxide (Dupont et al. 2003; Deykin et al. 2002; Smith et al. 2004; Berkman et al. 2005; Zitt 2005). Patients perform a slow expiratory vital capacity maneuver with a constant flow rate. The optimal cutoff point of exhaled nitric oxide still needs to be established. Thus far, measuring exhaled nitric oxide has not been commonly used in epidemiologic studies.

Summary

A number of methods exist to identify asthma in patients and study participants, each of which has advantages and disadvantages. Because there is no "gold standard" to assess asthma, the validity of the different methods is difficult to establish. A clinical diagnosis of asthma derived by following professional guidelines is often used as the "gold standard." The choice of which test to incorporate in a study will be based on the perceived accuracy of a test as well as on practical considerations involving cost, invasiveness, complexity, and patient acceptability. Attempts have been made to assess the validity of different methods in diagnosing asthma (Hunter et al. 2002; Yurdakul et al. 2005). The findings of inconsistent rates of asthma across four different data sources used routinely for surveillance purposes in the United Kingdom sound a note of caution about the use of such data (Hansell et al. 2003).

Prevalence of Asthma

Estimates of the prevalence of asthma show tremendous temporal and spatial variation (Pearce and Douwes 2006). In the United States, several data systems provide information about the prevalence of asthma including National Health and Nutrition Examination Surveys, National Health Interview Surveys (NHIS), Behavioral Risk Factor Surveillance System (BRFSS), and ISAAC. Estimates from these surveys are all based on the results from questionnaires. Data from the NHIS show that the prevalence of asthma, based on a household member having had asthma during the previous 12 months, in the US population rose from <4% to approximately 5.5% in 1996 (Mannino et al. 2002). In 2004, 9.9% of US adults representing an estimated 21.3 million people had ever had asthma, and 6.4% or approximately 14.4 million still had asthma (Centers for Disease Control and Prevention 2006a). In 2004, 12.2% of US children representing an estimated 8.9 million children were ever diagnosed with asthma, and 5.4% or 4 million children had experienced an attack in the past 12 months (Centers for Disease Control and Prevention 2005). Data from the BRFSS administered to participants aged 18+ years showed a steady rise in the prevalence of lifetime asthma ("Did a doctor ever tell you that you had asthma?") from 10.4% in 2000 to 13.3% in 2004 and that of current asthma ("Do you still have asthma?") from 7.2% to 8.1% (Fig. 1.1) (Centers for Disease Control and Prevention 2004a). In contrast, the prevalence of ever having asthma or having an asthma attack in the past 12 months among children varied only slightly from 1997 through 2004, according to NHIS data (Fig. 1.2) (Centers for Disease Control and Prevention 2005; Centers for Disease Control and Prevention 2002a, b; Centers for Disease Control and Prevention 2003a, b, c; Centers for Disease Control and Prevention 2004b; Centers for Disease Control and Prevention 2006b). Previously, the prevalence of having asthma during the previous 12 months in children increased from 3.6% in 1980 to 6.2% in 1996 (Akinbami and Schoendorf 2002).

Age, Sex, and Race or Ethnicity

In general, the prevalence of ever having asthma and having an asthma attack in the past 12 months increases progressively during childhood (Fig. 1.3). In addition, during childhood, the prevalence of ever having asthma and having an asthma attack in the past 12 months is higher among males than females (Fig. 1.4), whereas among adults the prevalence of lifetime asthma and current asthma is generally higher among females than males (Fig. 1.5). US data from the 2004 NHIS show somewhat varying patterns in the prevalence of ever having asthma with respect to age (Figs. 1.3 and 1.6). The prevalence of ever having asthma is highest among those aged 12–17 years. Among adults, relatively little variation in the prevalence of ever having asthma by age group is present. In contrast, the prevalence of still having asthma increases gradually with age through ages 65–74 years. Of the three major racial or ethnic groups, the prevalence of ever having asthma is highest among African American children and lowest among Hispanic children (Fig. 1.7) (McDaniel et al. 2006). Racial or ethnic differences among adults were similar to those among children except that the difference between whites and African Americans was less pronounced (Fig. 1.8).

Geographic Variability Within Countries

BRFSS data for the United States show significant variation among the fifty states and two territories

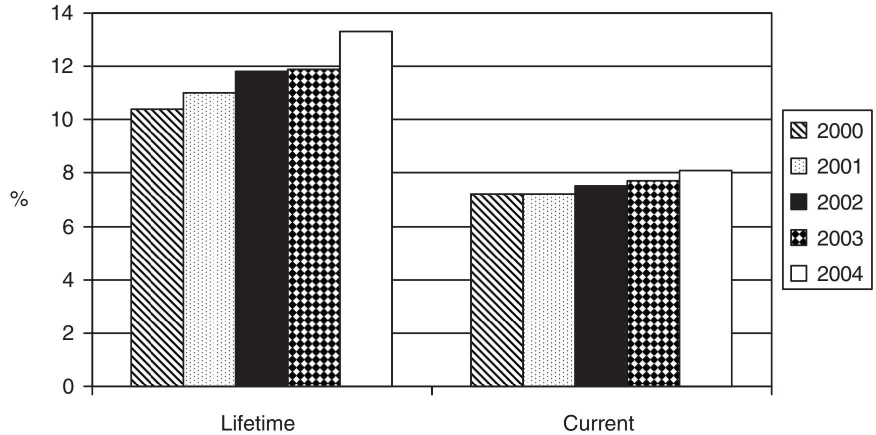

Fig. 1.1 Trend in the prevalence of asthma among US adults aged ≥18 years with asthma, Behavioral Risk Factor Surveillance System, 2000–2004

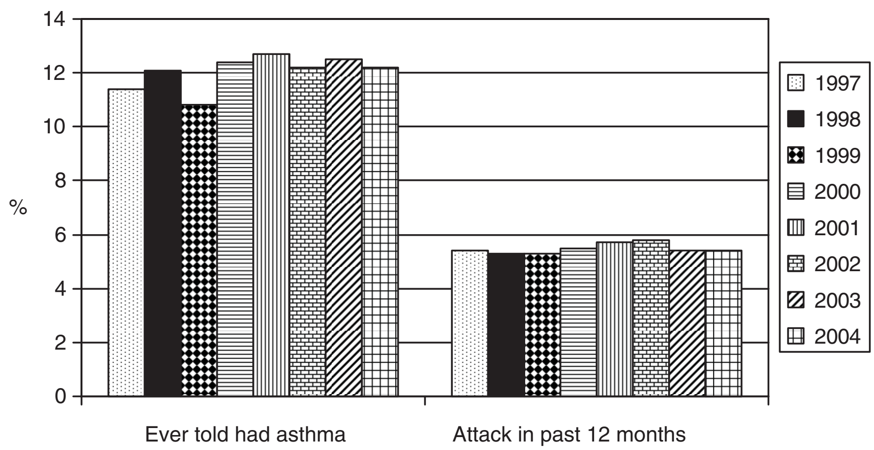

Fig. 1.2 Trend in the prevalence of asthma among US children aged <18 years with asthma, National Health Interview Survey, 1997–2004

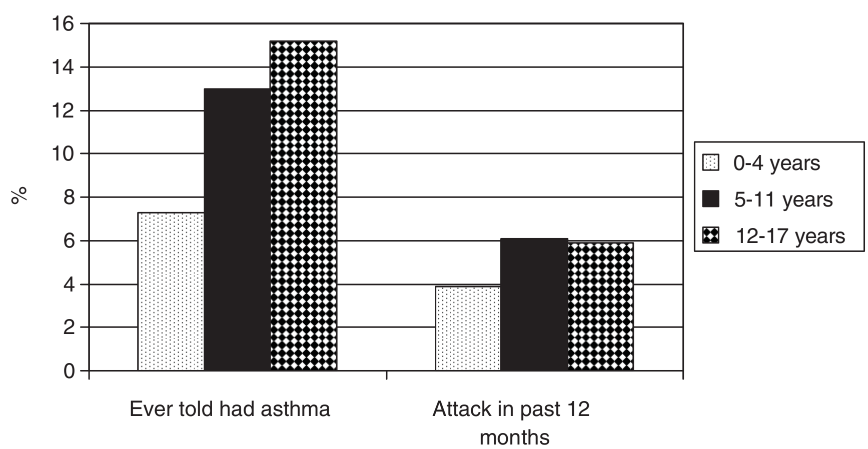

Fig. 1.3 Age-specific percentage of US children aged <18 years with asthma, National Health Interview Survey, 2004

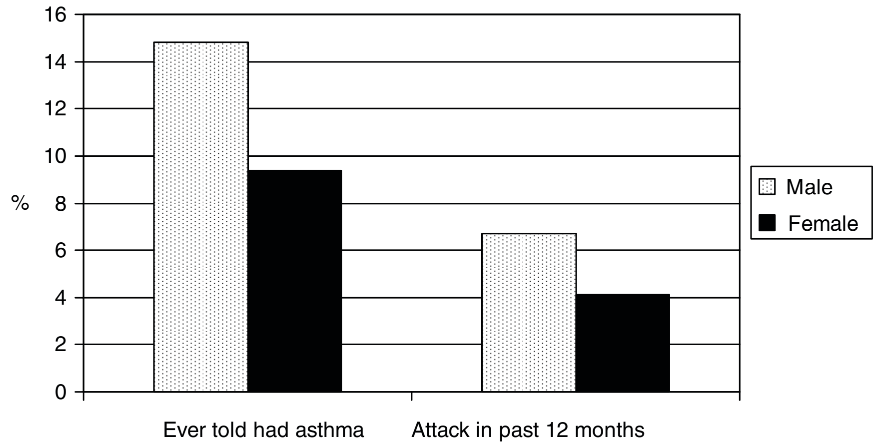

Fig. 1.4 Age-adjusted percentage of US children aged <18 years with asthma, by gender, National Health Interview Survey, 2004

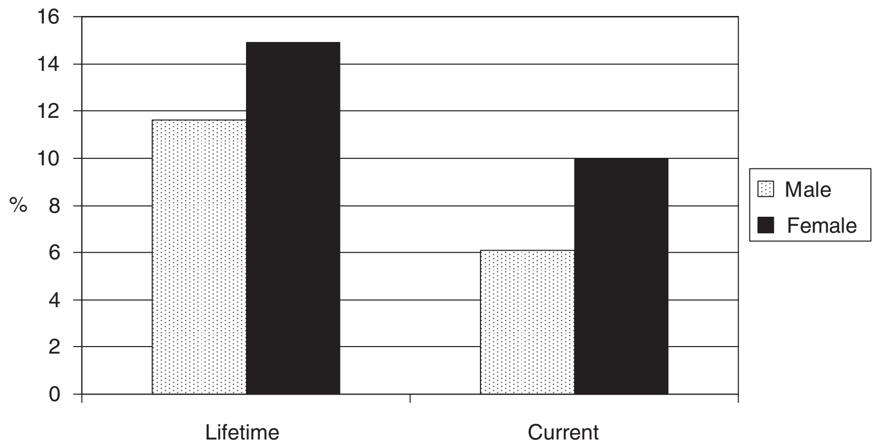

Fig. 1.5 Age-adjusted percentage of US adults aged ≥18 years with asthma, by gender, Behavioral Risk Factor Surveillance System, 2004

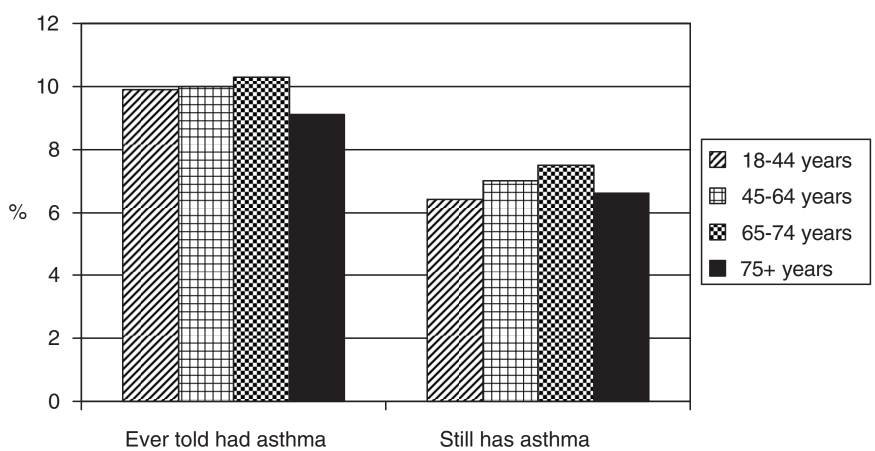

Fig. 1.6 Age-specific percentage of US adults with asthma, National Health Interview Survey, 2004

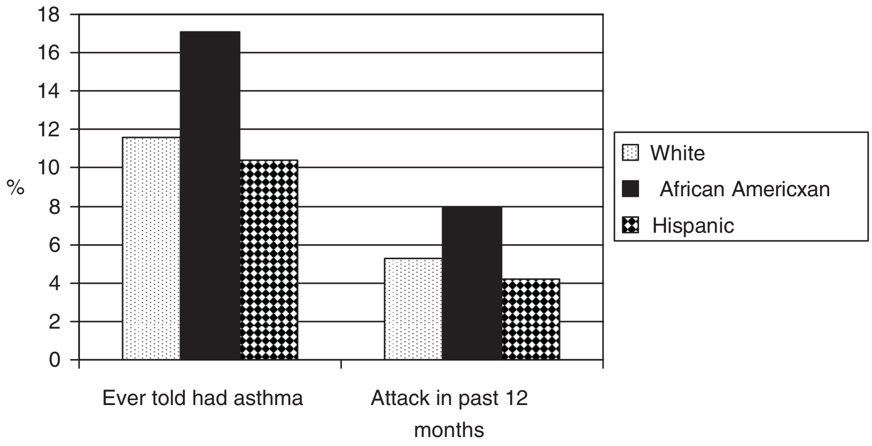

Fig. 1.7 Age-adjusted percentage of US children aged <18 years with asthma, by race or ethnicity, National Health Interview Survey, 2004

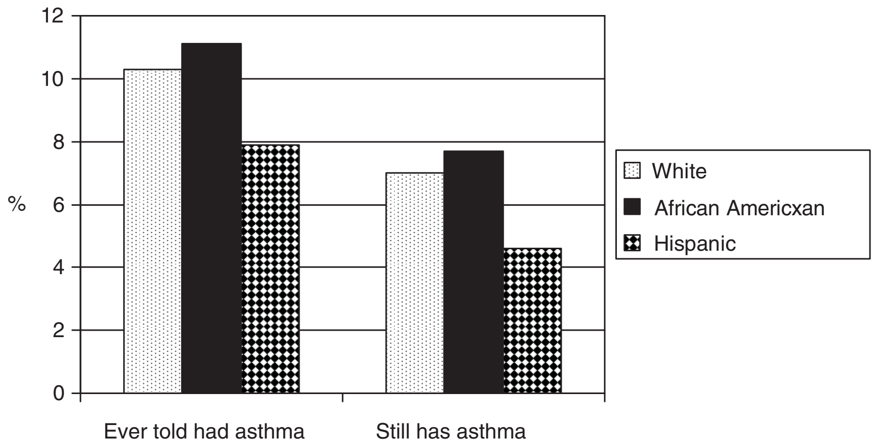

Fig. 1.8 Age-adjusted percentage of US adults aged ≥18 years with asthma, by race or ethnicity, National Health Interview Survey, 2004

(Figs. 1.9 and 1.10). In 2004, the lifetime prevalence of asthma ranged from 10.3% in South Dakota and the Virgin Islands to 16.3% in Oregon and 18.8% in Puerto Rico, whereas the prevalence of current asthma ranged from 4.6% in the Virgin Islands to 10.3% in New Hampshire (Centers for Disease Control and Prevention 2004a). In addition, data from ISAAC also show significant variation within other countries such as Brazil, India, Italy, Spain, and the United Kingdom (ISAAC Steering Committee 1998).

Geographic Variability Among Countries

ISAAC was conducted in 56 countries among children aged 13–14 years using standardized techniques (ISAAC Steering Committee 1998). The results showed enormous variation in the prevalence of 12-month asthma ranging from 1.6% in Indonesia to 36.8% in the United Kingdom. Other data reviewed by Pearce and Douwes show equally dramatic variation in the prevalence of asthma across the world

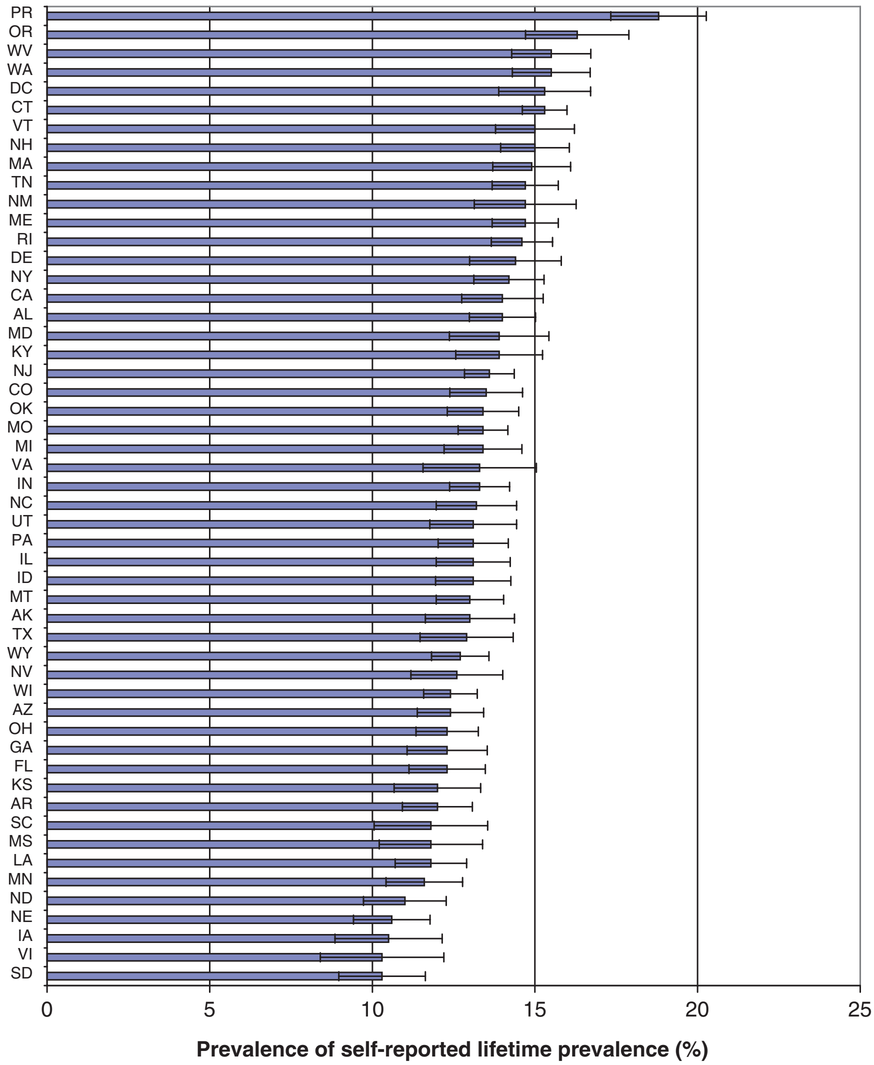

Fig. 1.9 Prevalence of self-reported lifetime asthma (percent, 95% confidence interval), by state or territory, Behavioral Risk Factor Surveillance System, 2004

(Pearce and Douwes 2006). Among children, adolescents, and young adults, the prevalence ranges from 0% in Papua, New Guinea during 1973–1984 to 33.9% in the United Kingdom during 1991–1998. Furthermore, the European Community Respiratory Health Survey conducted among participants aged 20–44 years showed that estimates of diagnosed asthma ranged from 2% in Tartu, Estonia to 8.4% in Cambridge, United Kingdom during the early 1990s (ECRHS 1996).

Temporal Trends

Studies from the 1950s to the 1990s found increases in prevalence of asthma and asthma symptoms in many countries (Robertson et al. 1991; von Mutius 1998). However, in the last 10–15 years, the prevalence of asthma or asthma symptoms has either reached a plateau or decreased in several countries (Robertson et al. 2004). Many of these studies documenting the trends used questionnaires. However, increases in

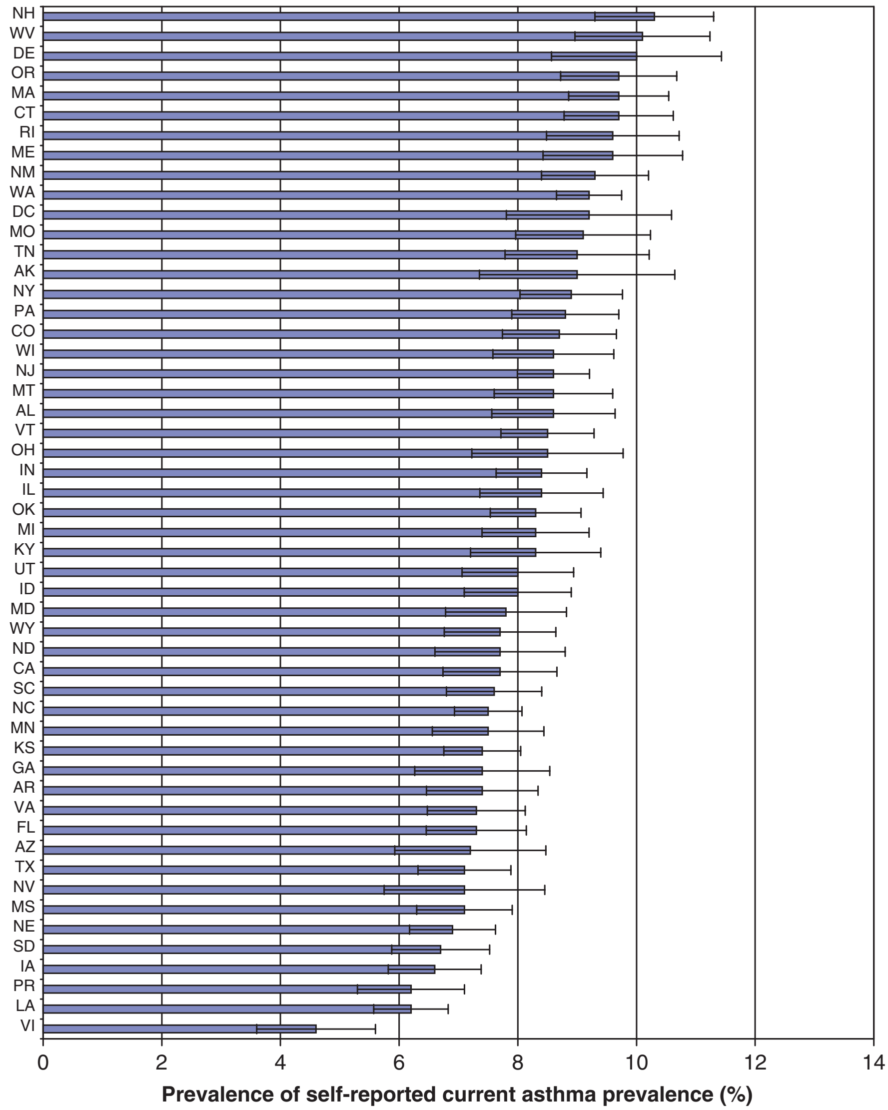

Fig. 1.10 Prevalence of self-reported current asthma (percent, 95% confidence interval), by state or territory, Behavioral Risk Factor Surveillance System, 2004

bronchial hyperreactivity in children over time have been documented as well (Burr et al. 1989; Peat et al. 1994).

Incidence of Asthma

Incidence data at the national level is difficult to come by. However, numerous cohort studies provide some insights into the incidence of this disease. In a recent review of 40 prospective studies from 13 countries, the incidence of asthma ranged from 0.6 to 29.5 per 1,000 persons (King et al. 2004).

Medical Care Utilization

Hospitalizations

Despite some instability in the annual rates of hospitalization for asthma in the United States, the estimated rate generally decreased from 1985 to 1999 (from 19.7 to 17.6 per 10,000 population) (Mannino et al. 2002). Because of a growing population, however, the number of such hospitalizations was 408,000 in 1980 and 478,000 in 1999. The trend in the rate of hospitalization differed by sex, ethnicity, and age. The highest rates in men occurred in 1980 and 1985, whereas among women the highest rate occurred in 1995. The highest rate occurred in 1997 among those aged <4 years, in 1995 in those aged 5–34 years, in 1980 among those aged 35–64 years, and in 1985 among those aged 65+ years. Among whites, the rate peaked in 1985 before decreasing (15.6 per 10,000 population in 1985 to 10.6 per 10,000 population in 1999), whereas in African Americans, the rate peaked in 1995 (from 40.7 per 10,000 population in 1985 to 35.6 per 10,000 population in 1999). In all years, rates were higher in women than men, in African Americans than whites, and were highest in those aged ≤4 years and lowest in those aged 15–34 years. More recent data through 2002 show further decreases in hospitalization rates among whites but not African Americans (Getahun et al. 2005).

In other countries, rates of hospitalization for asthma have varied in time as well. In Scotland, the rate of hospitalization increased overall between 1981 and 1997 (from 106.7 to 236.7 per 100,000 population) (Morrison and McLoone 2001). However, among those aged <15 years, the rates peaked in 1992 and then decreased progressively through 1997. In contrast, rates continued to increase in those aged 15+ years. Furthermore, trends differed between males and females. In northeastern Israel, the rate of first hospital admission for asthma increased, but that of readmission decreased among children aged <18 years from 1990 to 1999 (Rottem et al. 2005). In Norway, the rate of admissions increased among children aged <15 years during the 1980s before decreasing and stabilizing (29.5 per 10,000 during 1980–1985, 36.3 per 10,000 during 1986–1990, and 33.0 per 10,000 during 1991–1995) (Jonasson et al. 2000). After peaking in 1984 and 1985, rates of readmissions decreased. In addition, the age at admission and length of hospital stay decreased. In Athens, Greece, the admission rate for children aged <15 years rose by 271% from 1978 to 2000 (Priftis et al. 2005). Admission rates were higher among children aged <4 years than among those aged 5–14 years. In Eastern Finland, hospital admissions for asthma among children aged ≤16 years increased from 1.2 per 1000 in 1988 to 2.7 per 1,000 in 1997 (Korhonen et al. 2002). The readmission rate decreased, however. At a nationwide institution in Mexico, the rate of hospitalizations among people of all ages increased from 1991 to 1996 and then decreased progressively through 2001 (Vargas et al. 2004). Although some variability was present in the age-specific trends, the rates in all age groups decreased since 1999. In Victoria, Australia, the admission rates decreased from 3.11 per 1000 population in 1993–1994 to 2.15 per 1,000 population in 1999–2000 (Ansari et al. 2003). A decrease in hospitalization rates was also observed in Singapore (from 21.7 per 10,000 population in 1991 to 15.4 per 10,000 population in 1998) (Ng et al. 2003) and in Ontario from 1988 to 2000 (Crighton et al. 2001). Interestingly, the rate of hospitalization changed little in Quebec from 1988 to 1989 (1.76 per 1,000 population) to 1994–1995 (1.75 per 1,000 population) (Laurier et al. 1999). In contrast, admission rates in Taiwan increased among children aged 2–14 years from 1990 to 1998 (Kao et al. 2001) and among children from South Africa from 1986 to 1996 (MacIntyre et al. 2001).

Emergency Room Visits

The number of visits to the emergency room for asthma in the United States increased steadily, from an estimated 1,467,000 in 1992 to 1,997,000 in 1999, whereas the rate of these visits was lowest in 1992 (56.8 per 10,000 population) and bounced between 70 and 75 per 10,000 population between 1995 and 1999 (Mannino et al. 2002). Rates were markedly higher in African Americans than whites (in 1995 over four times higher), and more modestly so among women than men. In addition, rates were highest among children ≤4 years. In a Mexican nationwide institution, the rate of emergency room visits increased from 1991 to 1996 and then decreased steadily through 2001 (Vargas et al. 2004).

Physician-Office Visits

The annual number of office visits to physicians for asthma in the United States also increased over time from approximately 5,921,000 in 1980 to 13,853,000 in 1998 and 10,808,000 in 1999 (Mannino et al. 2002).

The rate of these visits increased from 26.1 per 1,000 population in 1980 to 51.5 per 1,000 population in 1998. The differential between African Americans and whites was much less pronounced, whereas the rate among women was consistently higher than that among men. In addition, the rate was highest among those aged 5–14 years. In a Mexican nationwide institution, the rate of office visits to family physicians increased from 1991 to 1995, was stable in 1996 and 1997, and then decreased through 2001 (Vargas et al. 2004).

Economic Impact

The estimated direct and indirect costs of asthma have continued to escalate in the United States. The costs of asthma were calculated to be $4.5 billion in 1985 (Weiss et al. 2000), $6.2 billion in 1990 (Weiss et al. 1992), $10.7 billion in 1994 (Weiss et al. 2000), $12.7 billion in 1998 (Weiss and Sullivan 2001), and $19.7 billion in 2009 (American Lung Association 2009). Estimates have also been generated in other countries. For example, the indirect and direct costs of asthma were estimated at $32 million in 1992/1993 dollars in Singapore (Chew et al. 1999), CAN$810-954 million in Canada in 1990 (Krahn et al. 1996), 2.74 billion euros in Germany during in 1999 (Stock et al. 2005), 1.252 billion Swiss franks in Switzerland in 1997 (Szucs et al. 1999), 1.9 billion Danish kronen in 2000 (Mossing and Nielsen 2003), and 0.9–1.2 billion euros in Spain (Nieto et al. 2001). In addition, direct costs were 2.1 million euros in Estonia in 1997 or approximately 1.4% of direct health care costs (Kiivet et al. 2001). Finally, the costs for children aged <15 years living in one of the 25 countries in Europe were approximately 3 billion in 2004 euros (van den Akker-van Marle et al. 2005).

Asthma Mortality

In the United States, the race-, sex-, and age-adjusted mortality rate for asthma increased from 1980 until about the mid 1990s and then decreased through 1998 (Mannino et al. 2002). Since then, the number of deaths for which asthma was listed as the underlying cause was 4,657 in 1999, 4,487 in 2000, 4,269 in 2001, and 4,261 in 2002. During these 4 years, the age-adjusted mortality rate dropped from 1.3 to 1.2 per 100,000 population in males and from 2.0 to 1.7 per 100,000 population in females. The mortality rate increased with age and reached a maximum for those aged 85+ years. The mortality rate decreased among both whites (from 1.4 to 1.2 per 100,000) and African Americans (from 3.9 to 3.4 per 100,000) but remained approximately 2.8 to 3.0 times higher among African Americans.

A comparison of mortality rates from asthma for populations aged 5–34 years from 14 countries from 1970 through the mid 1980s showed large variation in mortality rates and in most countries increases in the mortality rates (Jackson et al. 1988). In the United Kingdom, the mortality rates from asthma during the period from 1983 to 1995 declined in age groups younger than 75 years (Campbell et al. 1997). For those aged 75 years and older, rates were either roughly stationary or increased. In Denmark, mortality trends for those aged 1–19 years increased from 1973 until about 1983–1987 for most age groups before decreasing though 1993–1994 (Jorgensen et al. 2000). Furthermore, mortality rates decreased in Capetown, South Africa in all racial groups between 1980 and 1997 (Zar et al. 2001). In contrast, mortality rates from asthma remained relatively stable between 1980 and 1997 among Israelis aged 5–34 years (Picard et al. 2002).

Comparing mortality rates among countries is complicated by coding practices in countries, changes in International Classification of Diseases codes over time (ICD-8, ICD-9, and ICD-10), and changes in diagnostic practices by clinicians. It appears, however, that mortality rates have fallen in many countries, although the time points when the decreases commenced may have differed.

Disability-Adjusted Life-Years (DALY)

The World Health Organization (WHO) defines the DALY as “a health gap measure that extends the concept of potential years of life lost due to premature death (PYLL) to include equivalent years of ‘healthy’ life lost by virtue of being in states of poor health or disability. The DALY combines in one measure the time lived with disability and the time lost due to premature mortality. One DALY can be thought of as one lost year of ‘healthy’ life and the burden of disease as a measurement of the gap between current health status and an ideal situation where everyone lives into old age free of disease and disability” (World Health Organization 2009). Thus, the DALY is a measure of the state of health of a population that reflects both the loss of quality of life and loss of life years (Murray 1994). One DALY reflects the loss of one healthy life year. In 2001, WHO attributed approximately 15 million DALYs to asthma worldwide, or approximately 1% of the total DALYs for all causes that were considered (World Health Organization 2002).

Risk Factors

Numerous epidemiological studies have examined a host of factors as predictors of asthma incidence or correlates of prevalence. A number of these are listed in Table 1.2. Because subsequent chapters will provide a detailed look at these factors, we will content ourselves with some general remarks. Despite a lengthy list of potential risk factors, few have been subjected to systematic review.

The distinction between a risk factor and trigger in studies of asthma etiology is not always straightforward. Although a particular factor could be both, it is also possible that it could be one or the other. Furthermore, another distinction needs to be drawn between a risk factor and a risk marker. The former implies that the factor is causally related to the disease, whereas the latter predicts disease but is not causally related to the disease. The distinction is important because a risk factor is potentially amenable to intervention, whereas a risk marker is not. Nevertheless, risk markers may still be useful in identifying groups of people at increased risk of developing asthma.

Some studies have suggested complex interactions between risk factors and the risk of asthma or asthma symptoms. Examples of reported interactions between factors include atopy and smoking (Sunyer et al. 1997), age and exposure to pets (Apelberg et al. 2001), atopic heritability and home dampness (Kilpelainen et al. 2001b), parental history of asthma and exposure to pets (Celedon et al. 2002), gender and smoking status and/or exposure to pets (Chen et al. 2002), genetic factors and environmental factors (Bisgaard 2004), and diet and indoor allergen exposure (Kim et al. 2005).

Table 1.2 Purported risk and protective factors for asthma

Risk factors
Sociodemographic
Age
Gender
Ethnicity
Acculturation
Socioeconomic status
Infections
Host factors
Atopy
Allergies
House mites
Cockroaches
Pollen
Pets
Environmental
Indoor air pollution
Outdoor air pollution
Environmental tobacco smoke
Bio-aeroallergens
Lifestyle
Smoking
Exercise
Nutrition
Obesity
Developmental
Low birth weight
Breastfeeding
Occupational exposures
Genetics
Protective factors
Breastfeeding
Menopause
Daycare attendance
Pet ownership
Parasites

Determinants of early-onset asthma may also differ from those of late-onset asthma. Because the bulk of asthma among children and adolescents occurs at a young age, studies of risk factors in pediatric populations have to be done among young children (Weiss 2001).

Finally, although some risk factors may be strongly related to asthma, as evidenced by large measures of association (i.e., odds ratios, relative risks, or hazard ratios), they may occur relatively rarely. Conversely, some risk factors for asthma may be more modestly associated with asthma incidence yet occur much more frequently in the population. The population attributable risk, also known by several other names, combines estimates of relative risk and prevalence into a single measure. This statistic is, therefore, important from a public health perspective because it can help to prioritize prevention strategies and allocate resources appropriately.

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