Asthma Prevalence, Health Care Use, and Mortality: United States, 2005–2009

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Abstract

Objectives—This report presents recent data on asthma prevalence and health care use. Additional data on school and work absences and asthma management practices are also presented. Where possible, differences are examined by age, sex, race or ethnicity, geographic region, poverty status, and urbanicity.

Methods—Data from the National Health Interview Survey, the National Ambulatory Medical Care Survey, the National Hospital Ambulatory Medical Care Survey, the National Hospital Discharge Survey, and the National Vital Statistics System were used to calculate national estimates. The most recent data available from each system are presented, and 3-year annual averages are used to increase the reliability of estimates for subgroups where necessary.

Results—In 2009, current asthma prevalence was 8.2% of the U.S. population (24.6 million people); within population subgroups it was higher among females, children, persons of non-Hispanic black and Puerto Rican race or ethnicity, persons with family income below the poverty level, and those residing in the Northeast and Midwest regions. In 2008, persons with asthma missed 10.5 million school days and 14.2 million work days due to their asthma. In 2007, there were 1.75 million asthma-related emergency department visits and 456,000 asthma hospitalizations. Asthma emergency visit and hospitalization rates were higher among females than males, among children than adults, and among black than white persons. Despite the high burden from adverse impacts, use of some asthma management strategies based on clinical guidelines for the treatment of asthma remained below the targets set by the Healthy People 2010 initiative.

Keywords: school and work absence ● ambulatory care ● emergency department visits ● hospitalizations

Introduction

Asthma is a chronic respiratory disease characterized by episodes or attacks of impaired breathing. Symptoms are caused by inflammation and narrowing of small airways and may include shortness of breath, coughing, wheezing, and chest pain. Disease severity ranges from mild with occasional symptoms to severe with persistent symptoms that impact quality of life. However, even people with mild disease may suffer severe attacks. Common attack triggers include airway irritants (e.g., tobacco smoke and air pollution), allergens, respiratory infections, stress, and exercise (1).

Although little is understood about preventing asthma from developing, the means for controlling and preventing symptoms are well established. Treatment includes the use of medication for short-term relief; daily use of preventive medication to avert attacks; monitoring of early symptoms; avoiding factors that trigger attacks; and removing risks (e.g., tobacco smoke or mold) from the home, school, and work environments. Nevertheless, morbidity, direct health care costs, indirect costs such as lost productivity, and mortality due to asthma continue pose a high burden in the United States. The present

report presents estimates for asthma prevalence in the United States, as well as for asthma-related health care use and mortality. Differences between groups are presented where data are available.

Methods

Data sources

Estimates for asthma prevalence, school and work absences, and asthma control measures are based on data from the National Health Interview Survey (NHIS). NHIS serves as a principal source of health information for the U.S. civilian noninstitutionalized population. Questions used to ascertain asthma prevalence are contained in the core questionnaire asked of one sample adult in each family included in NHIS, and, if children are present, one sample child in the family for whom a responsible adult responds. Periodically, supplements with special content for asthma are included in the survey. In 2008, an asthma supplement ascertained aspects of disease control and asthma-specific absences from school and work (questionnaires for 2008 and other years can be viewed at: http://www.cdc.gov/nchs/nhis/nhis_questionnaires.htm). Definitions and question wording for estimates used in this report are found in the ''Technical Notes'' section.

Ambulatory visit numbers and rates were estimated using data from the National Ambulatory Medical Care Survey (NAMCS) and the National Hospital Ambulatory Medical Care Survey (NHAMCS). Visits to private physician offices were estimated using NAMCS, which samples visits made in the United States to offices of nonfederally employed physicians. Visits to private, nonhospital-based clinics, community health centers, and health maintenance organizations were included. Telephone contacts and visits made outside of physician offices were excluded. Visits to outpatient departments (OPDs) and emergency departments (EDs) were estimated using NHAMCS, which samples visits made to these departments in nonfederal short-stay hospitals (average stay fewer than 30 days) and in general hospitals

(medical or surgical) and children's general hospitals. EDs that operate fewer than 24 hours were included in the OPD component.

Data for asthma hospitalization numbers and rates were obtained from the National Hospital Discharge Survey (NHDS). NHDS is a national probability survey that collects data from a sample of inpatient records acquired from a national sample of nonfederal short-stay hospitals in the United States. Only hospitals with an average length of stay of fewer than 30 days for all patients, and general hospitals and children's general hospitals were included in the survey.

Asthma death data were obtained from the National Vital Statistics System (NVSS). NVSS includes data on births and deaths based on U.S. standard certificates. The mortality component was used to report asthma death rates.

Statistical analyses

For all health care surveys used in this analysis (NAMCS, NHAMCS, and NHDS), *International Classification of Diseases, Ninth Revision* (ICD–9–CM) code 493 was used to identify asthma. Asthma deaths were those with an underlying cause of death classified to the *International Classification of Diseases, Tenth Revision* (ICD–10) codes J45–J46.

To calculate national numbers and percentages from NHIS, NAMCS, NHAMCS, and NHDS, survey weights were used to inflate survey counts to national counts (2). All estimates and standard errors were estimated using SUDAAN software (3) to account for the complex sampling design of these surveys. Only reliable estimates—those with a relative standard error less than or equal to 30%—are presented in this report. Total population numbers and rates for the most recent single year are presented, whereas for subgroups, 3-year annual averages from NAMCS, NHAMCS, NHDS, and NVSS are presented to ensure stable estimates. Differences between percentages were evaluated using two-sided significance tests at the 0.05 level. No adjustments were made for multiple comparisons.

Terms such as ''similar'' and ''no difference'' indicate that the estimates being compared were not significantly different. However, lack of comment regarding the difference between any two statistics does not necessarily suggest that the difference was tested and found to be not significant.

The prevalence rate estimates shown in Figure 2 (except age-specific estimates) were age-adjusted using the direct method and the 2000 U.S. standard population. However, prevalence numbers, health care use numbers and rates, and mortality numbers and rates were not age-adjusted, to allow evaluation of crude estimates of health care utilization and mortality.

The denominators for the rates of health care use and mortality per the population with current asthma were obtained from NHIS. These denominators are the estimated annual average number of persons within the specified group with reported current asthma during the period 2005–2007. Relative standard errors for these rates were calculated using both the standard error of the numerator and the denominator.

More information concerning data sources and statistical analyses is provided in the ''Technical Notes'' section.

Results

Asthma prevalence continues to increase (Figure 1 and Table 1)

In 2009, current asthma prevalence was 8.2%, affecting 24.6 million people in the United States (17.5 million adults and 7.1 million children aged 0–17 years) (Table 1). Asthma attack prevalence—the proportion of the population with at least one attack in the previous year—was 4.2%. That is, 12.8 million people (8.7 million adults and 4.0 million children aged 0–17), or 52% of those with current asthma, had attacks and were at risk for adverse outcomes such as ED visits or hospitalization. The most rapid growth in asthma prevalence occurred from
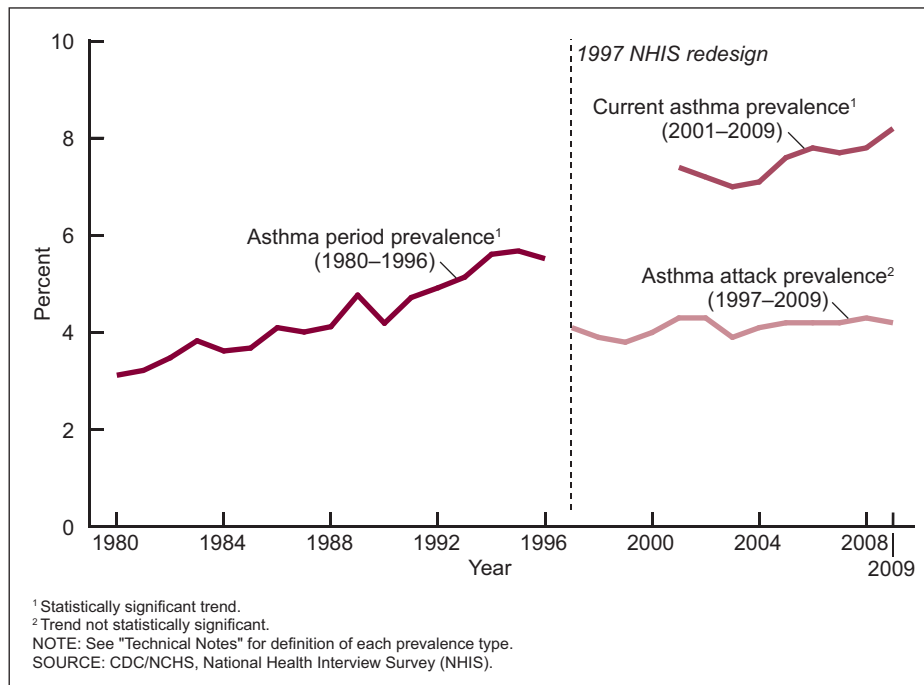
Figure 1. Asthma period prevalence, asthma attack prevalence, and current asthma prevalence for all ages: United States, 1980–2009

1980 to 1996, when asthma period prevalence grew from 3.5% to 5.5%, an annual percentage increase of 3.8%. In 1997, survey measures changed to capture more detailed aspects of asthma prevalence, and estimates before and after the change cannot be directly compared. The measure most comparable to the pre-1997 asthma period prevalence estimate is current asthma prevalence, which had remained stable (at 7.4%) since it first became available in 2001 but recently began increasing so that overall, the annual percentage increase from 2001 to 2009 was 1.2%. Asthma attack prevalence remained level between 3.9% and 4.3% during 1997–2009.

Asthma prevalence differs by demographic characteristics (Figure 2, Table 2, and Figure 3)

Significant differences in current asthma prevalence exist between many population subgroups. Figure 2 compares 2009 current asthma prevalence between population subgroups. Overall, females have higher current asthma prevalence than males, although among children aged 0–17, boys have a higher prevalence (11.3%) than girls (7.9%). Children have higher current asthma prevalence than adults. Compared with white persons,
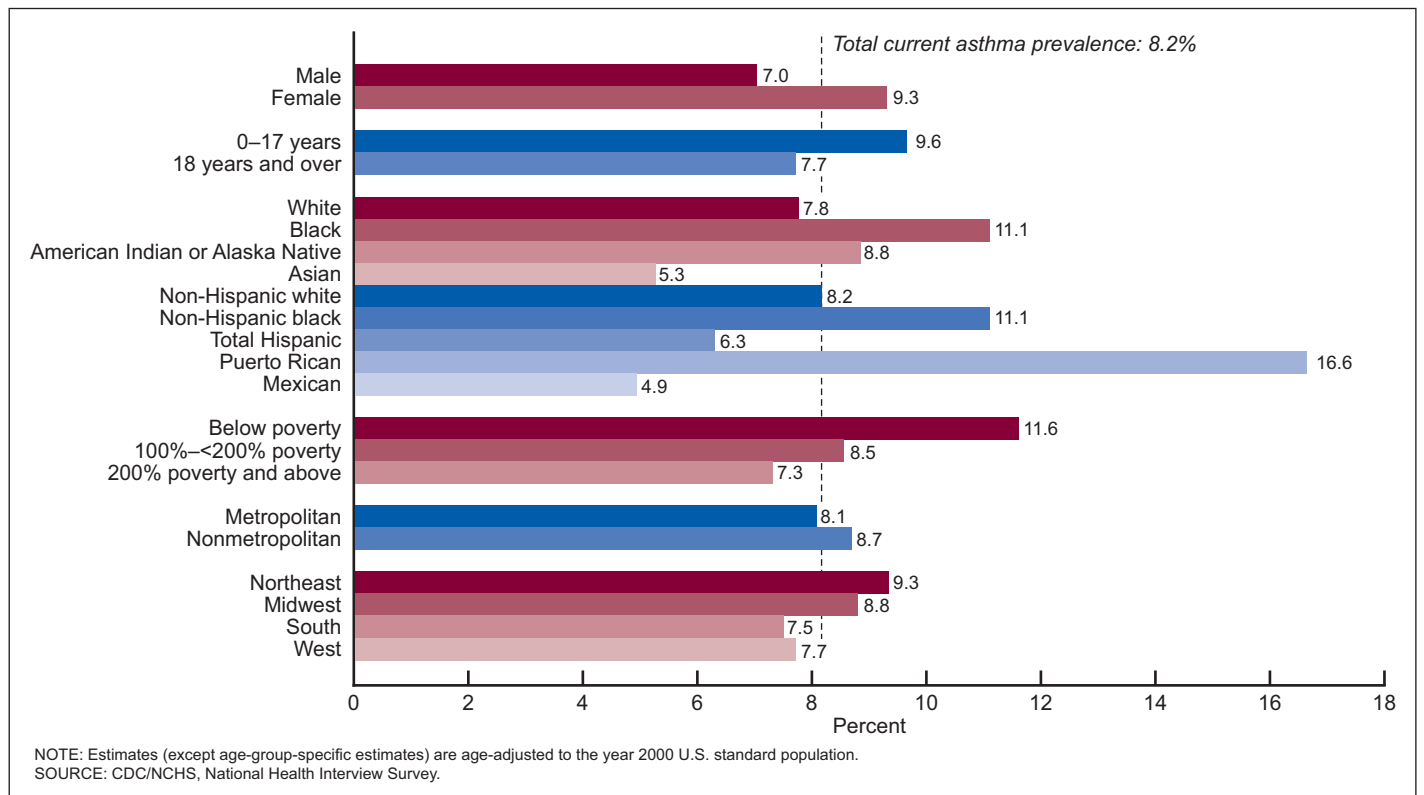

Figure 2. Prevalence of current asthma, by selected characteristics: United States, 2009

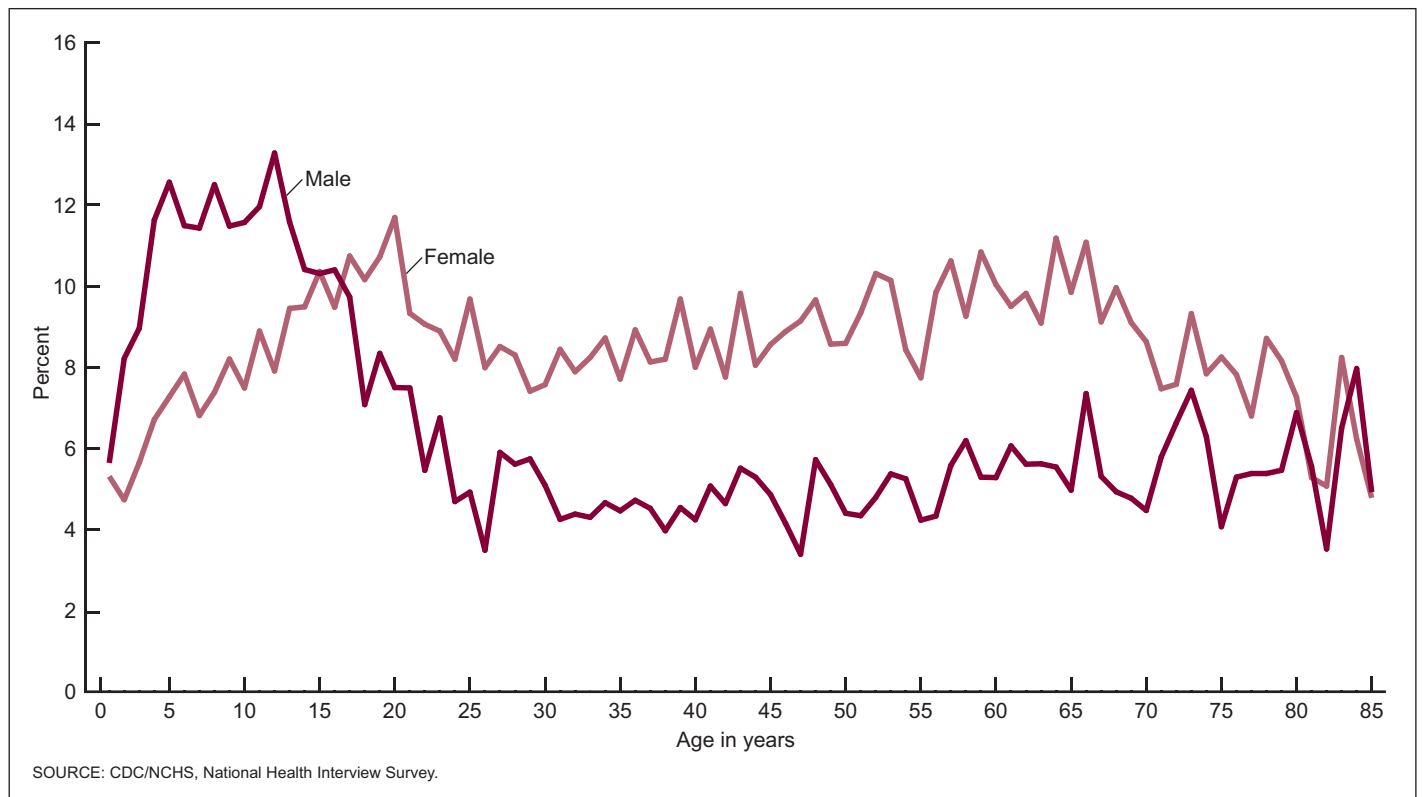SOURCE: CDC/NCHS, National Health Interview Survey.

Figure 3. Prevalence of current asthma among males and females aged 1–85 years, by age: United States, annual average 2001–2009

prevalence is higher among black and lower among Asian persons. Compared with non-Hispanic white and non-Hispanic black persons, current asthma prevalence is higher among Puerto Rican and lower among Mexican persons. Those with family income below the federal poverty level have higher asthma prevalence than those with incomes in the near poor (100% to less than 200% of poverty) and not poor (200% of poverty and above) categories. The near poor also have higher prevalence compared with the not poor. There is no difference in prevalence rates between residents of metropolitan and nonmetropolitan areas, but when examined by geographic region, prevalence is higher in the Northeast than in the West and South and in the Midwest compared with the South.

Figure 3 shows sex differences in more detail across lifespan. Boys have higher prevalence than girls throughout most of childhood. During early adolescence, current asthma prevalence declines among males, whereas in females, current asthma prevalence rises steadily through childhood so that

between ages 14 and 17 years, prevalence rates are similar among boys and girls. This pattern of change continues to early adulthood so that throughout most of adulthood, women report higher current asthma prevalence compared with men.

School and work absences are common among persons with symptomatic asthma (Table 3)

In 2008, children aged 5–17 years with at least one asthma attack in the previous year were reported to miss 10.5 million school days in the past year. Nearly 60% had at least one asthma absence day in the past year, and 5.5% were reported to have an activity limitation due to asthma. An activity limitation is defined as a long-term reduction in a person's capacity to perform the usual kind or amount of activities associated with his or her age group as a result of a chronic condition. Adults aged 18 and over who had at least one asthma attack in the past 12 months and were currently employed

reported missing 14.2 million work days, and nearly 34% missed at least one work day due to asthma in the previous year. Among those employed, 6% of adults with at least one asthma attack in the previous year reported that a breathing problem caused an activity limitation. Missed work days were also measured among adults with at least one asthma attack in the past 12 months who were not currently employed and included missed days of work around the house. Among those not currently employed, 22 million days of housework or other types of activities were missed, and 27% of those with at least one asthma attack in the past 12 months reported an activity limitation caused by a breathing problem.

Health care use for asthma is high, and disparities remain in asthma health care use and mortality (Table 4 and Figure 4)

In 2007, 13.9 million visits for asthma were made to private physician offices (7.2 million for adults and 6.7
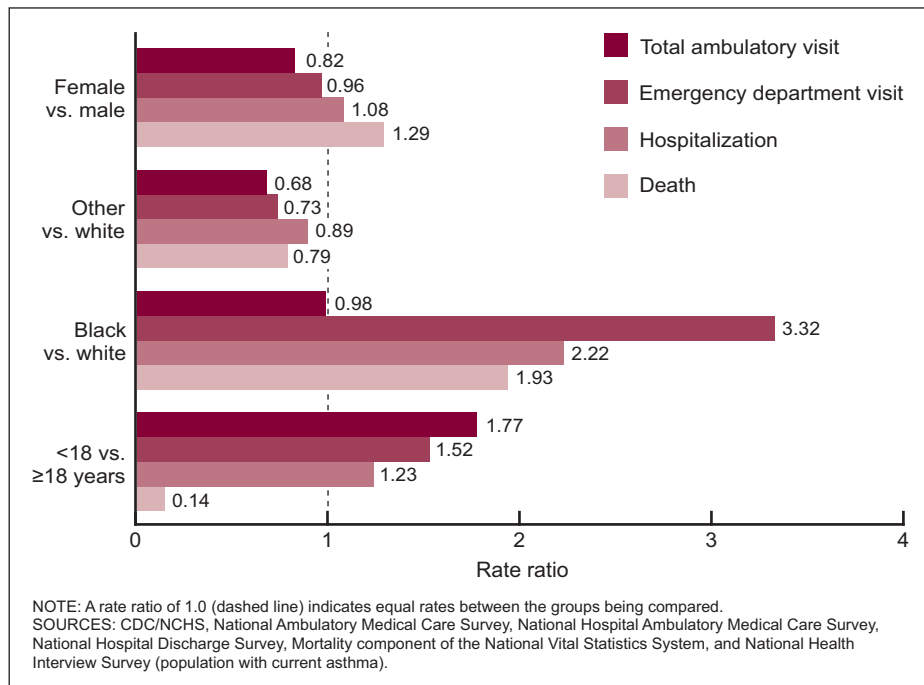
Figure 4. Relative burden of asthma health care use and mortality, adjusted for current asthma prevalence, by sex, race, and age group: United States, annual average 2005–2007

million for children aged 0–17 years) and 1.4 million visits to hospital OPDs (0.6 million for adults and 0.8 million for children aged 0–17 years). The National Heart, Lung, and Blood Institute guidelines for the clinical management of asthma recommend periodic preventive ambulatory visits for asthma monitoring, and a proportion of visits in nonemergent ambulatory settings may reflect appropriate disease management. In contrast, visits to EDs and hospital stays for asthma represent adverse outcomes. There were 1.75 million ED visits (1.11 million for adults and 0.64 million for children aged 0–17) and 456,000 asthma hospitalizations (299,000 for adults and 157,000 for children aged 0–17). There were 3,447 deaths due to asthma in 2007 (3,262 among adults and 185 among children aged 0–17).

To account for differing prevalence rates between groups and to focus on the population at risk for these outcomes, health care use rates in Table 4 were calculated per 100 persons with current asthma. Because numbers of asthma deaths are smaller, death rates were calculated per 10,000 persons with

current asthma. Estimates by income are not available, and less detail is available on health care use and mortality by race or ethnicity. Even after accounting for prevalence differences between groups, differences are seen in health care use and mortality burdens between groups. Health care use is highest among children aged 0–4 (rates per 100 persons with current asthma for total ambulatory visits were 144.9, for ED visits 24.6, and for hospitalizations 8.4). However, deaths from asthma are rare among children aged 0–17, with 174 deaths on average per year from 2005–2007.

To illustrate differences between groups, the rates in Table 4 were used to calculate the rate ratios shown in Figure 4. A rate ratio of 1.0 indicates equal rates between the groups being compared. The largest differences are seen for race and age groups. The black-to-white rate ratio was nearly 1.0 for total ambulatory visits but was greater than 1.0 for ED visits, hospitalizations, and deaths. The rate ratios for children compared with adults were above 1.0 for all types of health care services but below 1.0 for death.

Despite the large asthma burden and the existence of effective disease control strategies, some Healthy People 2010 targets for asthma management have not been met (Table 5)

The cornerstone of clinical guidelines for the management of asthma is control of symptoms and prevention of adverse outcomes (1). Some important components of guideline-recommended management that are also objectives of the Healthy People 2010 initiative (4) are shown in Table 5. In 2008, about 96% of people with current asthma reported that a health professional taught them how to use their inhaler, nearly meeting the target of 98.8%. However, 34% reported receiving an asthma management plan with specific instructions on how to change the amount or type of medicine taken, when to call a doctor for advice, and when to go to the ED, and 60% reported that they were taught how to recognize early signs and symptoms of an asthma episode. Report of receiving these asthma control strategies differed among groups, with generally higher rates among children than adults and among non-Hispanic black persons than non-Hispanic white and Mexican persons.

Summary

Although increases in asthma prevalence have slowed since the mid-1990s, asthma prevalence remains at historically high levels. Current asthma prevalence differs between groups, with higher rates among females, children, non-Hispanic black and Puerto Rican persons, those with family income below the poverty level, and those residing in the Northeast and Midwest regions. Asthma can involve costs related to health care use and morbidity, including missed work and school days. Even after accounting for prevalence differences between groups, health care use differs among groups. Non-Hispanic black persons have relatively low rates of ambulatory visits

compared with their use of urgent health care services, which may represent underuse of or lower access to preventive services. In contrast, although children have higher health care use than adults, they have much lower death rates. However, because adverse asthma outcomes are theoretically preventable, lowering asthma death rates among people of all ages remains a priority. The large asthma burden and continued adverse outcomes present an ongoing public health challenge, including the effort to enhance uptake of underutilized management strategies to control symptoms.

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Table 1. Asthma period prevalence, current asthma prevalence, and asthma attack prevalence, for all ages: United States, 1980–2009

Year	Asthma period prevalence	Current asthma prevalence	Asthma attack prevalence
	Percent (standard error)		
1980.	3.1 (0.2)	– – –	– – –
1981.	3.2 (0.2)	– – –	– – –
1982.	3.5 (0.2)	– – –	– – –
1983.	3.8 (0.2)	– – –	– – –
1984.	3.6 (0.2)	– – –	– – –
1985.	3.7 (0.2)	– – –	– – –
1986.	4.1 (0.3)	– – –	– – –
1987.	4.0 (0.2)	– – –	– – –
1988.	4.1 (0.2)	– – –	– – –
1989.	4.8 (0.2)	– – –	– – –
1990.	4.2 (0.2)	– – –	– – –
1991.	4.7 (0.2)	– – –	– – –
1992.	4.9 (0.2)	– – –	– – –
1993.	5.1 (0.3)	– – –	– – –
1994.	5.6 (0.3)	– – –	– – –
1995.	5.7 (0.3)	– – –	– – –
1996.	5.5 (0.3)	– – –	– – –
1997.	– – –	– – –	4.1 (0.1)
1998.	– – –	– – –	3.9 (0.1)
1999.	– – –	– – –	3.9 (0.1)
2000.	– – –	– – –	4.0 (0.1)
2001.	– – –	7.4 (0.1)	4.3 (0.1)
2002.	– – –	7.2 (0.2)	4.3 (0.1)
2003.	– – –	7.0 (0.2)	3.9 (0.1)
2004.	– – –	7.1 (0.2)	4.1 (0.1)
2005.	– – –	7.6 (0.2)	4.2 (0.1)
2006.	– – –	7.8 (0.2)	4.2 (0.1)
2007.	– – –	7.7 (0.2)	4.2 (0.1)
2008.	– – –	7.8 (0.2)	4.3 (0.1)
2009.	– – –	8.2 (0.2)	4.2 (0.1)

– – – Data not available.

NOTES: Data are shown in Figure 1. See "Technical Notes" for definition of each prevalence type.

SOURCE: CDC/NCHS, National Health Interview Survey.

Table 2. Current asthma prevalence, by selected characteristics: United States, 2009

Characteristic	Number (rounded to nearest hundred)	Percent[1] (standard error)
Total	24,566,700	8.2 (0.2)
Sex		
Male	10,325,400	7.0 (0.3)
Female	14,241,300	9.3 (0.3)
Age		
0–17 years	7,111,100	9.6 (0.4)
18 years and over	17,455,600	7.7 (0.2)
Race/ethnicity		
White	18,533,500	7.8 (0.2)
Black	4,273,400	11.1 (0.6)
American Indian or Alaska Native	233,700	8.8 (2.4)
Asian	721,600	5.3 (0.7)
Non-Hispanic white	15,957,300	8.2 (0.3)
Non-Hispanic black	4,068,700	11.1 (0.6)
Total Hispanic[2]	2,997,000	6.3 (0.4)
Mexican	1,458,300	4.9 (0.4)
Puerto Rican	707,200	16.6 (1.9)
Percent of poverty level		
Below 100%	5,086,900	11.6 (0.6)
100%–less than 200%	5,056,100	8.5 (0.4)
200% and above	14,423,700	7.3 (0.2)
Urbanicity		
Metropolitan	20.283,000	8.1 (0.2)
Nonmetropolitan	4,283,700	8.7 (0.5)
Geographic region		
Northeast	4,863,900	9.3 (0.5)
Midwest	6,384,500	8.8 (0.5)
South	8,027,100	7.5 (0.3)
West	5,291,200	7.7 (0.4)

[1]Age-adjusted to the year 2000 U.S. standard population, except age-group-specific estimates.

[2]Includes all Hispanic ethnicities, including Mexican, Puerto Rican, and others not shown separately.

NOTES: Data are shown in Figure 2. Numbers for subgroups may not sum to total due to rounding. Numbers for race and ethnicity groups will not sum to the total because not all race/ethnicity groups are shown separately in the table, but all are included in the total.

SOURCE: CDC/NCHS, National Health Interview Survey.

Table 3. School and work absences and percentage with activity limitation caused by asthma, among persons with at least one asthma attack in the past year: United States, 2008

Population	Weighted population size, in millions	Total days missed,[1] in millions (standard error)	Percent with one or more asthma absence days in past year[1] (standard error)	Percent with activity limitation caused by asthma or breathing problem (standard error)
Children 5–17 years	3.3	10.5 (1.3)	58.7 (3.6)	5.5 (1.2)
Adults 18 years and over, currently employed	4.9	14.2 (4.7)	33.5 (2.8)	6.2 (1.3)
Adults 18 years and over, not currently employed.	3.8	22.0 (5.9)	29.1 (3.1)	26.5 (2.7)

[1]Records with missing responses for days of school (1% among children aged 5–17 years), work (0.4% among adults currently employed), or housework or other activity (25.1% among adults not currently employed) missed due to asthma are excluded.

SOURCE: CDC/NCHS, National Health Interview Survey.

Table 4. Asthma health care use per 100 persons with current asthma, and asthma deaths per 10,000 persons with current asthma, by selected characteristics: United States, annual average 2005–2007

Characteristic	Per 100 persons with asthma					Deaths per 10,000 persons with asthma
	Office visits	Hospital outpatient visits	Total ambulatory visits	Emergency department visits	Hospitalizations	
	Number (standard error)					
Total.	54.8 (5.6)	5.6 (0.7)	60.4 (5.6)	7.5 (0.4)	1.4 (0.2)	1.6 (0.0)
Sex						
Male	61.6 (7.3)	5.8 (0.8)	67.4 (7.3)	7.7 (0.5)	1.3 (0.2)	1.4 (0.1)
Female	50.0 (6.2)	5.5 (0.7)	55.5 (6.2)	7.4 (0.5)	1.4 (0.2)	1.8 (0.0)
Race						
White	57.4 (6.3)	4.6 (0.6)	62.0 (6.3)	5.6 (0.4)	0.9 (0.1)	1.4 (0.0)
Black	49.4 (9.2)	11.5 (2.1)	60.9 (9.4)	18.6 (1.6)	2.0 (0.3)	2.7 (0.1)
Other	38.5 (9.5)	3.4 (0.8)	41.9 (9.5)	4.1 (0.8)	0.8 (0.2)	1.1 (0.1)
Ethnicity						
Hispanic	72.1 (19.8)	11.1 (2.3)	83.2 (19.9)	10.7 (1.2)	– – –	0.9 (0.1)
Non-Hispanic	52.4 (5.4)	4.8 (0.6)	57.2 (5.4)	7.1 (0.4)	– – –	1.7 (0.1)
Age						
Under 18 years.	77.5 (10.3)	9.7 (1.7)	87.2 (10.4)	9.9 (0.9)	1.6 (0.3)	0.3 (0.0)
18 years and over	45.4 (5.4)	3.9 (0.5)	49.3 (5.4)	6.5 (0.4)	1.3 (0.2)	2.1 (0.1)

– – – Data on Hispanic ethnicity are not available for hospitalization.

SOURCES: CDC/NCHS, National Ambulatory Medical Care Survey, National Hospital Ambulatory Medical Care Survey, National Hospital Discharge Survey, mortality component of the National Vital Statistics System, and National Health Interview Survey (population with current asthma).

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Table 5. Percentage (standard error) with current asthma, or parents of children with current asthma, who reported receiving key asthma education or management strategies from a health care professional, by selected characteristics: United States, 2008

Characteristic	Taught how to use an inhaler	Given an asthma management plan	Taught how to recognize early signs or symptoms of an asthma episode	Advised to change things at home, school, or work to improve asthma	Taught how to respond to an episode of asthma
Healthy People 2010 target	*98.8*	*40.0*	*68.0*	*50.0*	*68.0*
			Percent (standard error)		
Total.	95.9 (0.5)	34.2 (1.2)	60.0 (1.3)	50.9 (1.3)	68.2 (1.2)
Sex					
Male	96.0 (0.8)	35.4 (2.0)	61.1 (2.0)	48.7 (2.1)	67.8 (2.0)
Female	95.8 (0.7)	33.2 (1.6)	59.0 (1.6)	52.7 (1.6)	68.5 (1.5)
Race/ethnicity					
Non-Hispanic white	96.0 (0.7)	32.5 (1.6)	57.0 (1.7)	50.6 (1.7)	67.3 (1.6)
Non-Hispanic black	94.3 (1.4)	44.0 (2.8)	69.2 (2.4)	52.4 (2.7)	72.6 (2.4)
Puerto Rican	93.0 (2.8)	37.3 (6.4)	69.8 (6.2)	57.2 (6.7)	68.3 (6.3)
Mexican	97.7 (1.3)	28.8 (3.5)	54.7 (4.3)	42.3 (4.4)	58.7 (4.4)
Age					
Under 18 years.	95.9 (0.9)	44.3 (2.3)	72.1 (2.0)	53.2 (2.5)	78.4 (1.9)
18 years and over	95.9 (0.6)	29.9 (1.4)	54.8 (1.6)	50.0 (1.5)	63.8 (1.5)
Percent of poverty level					
Below 100%.	93.7 (1.6)	31.1 (2.6)	57.9 (2.9)	49.9 (2.9)	63.8 (2.8)
100%–less than 200%	94.5 (1.2)	33.6 (2.6)	58.7 (2.8)	52.5 (2.8)	65.2 (2.7)
200% and above	97.0 (0.6)	35.3 (1.6)	61.0 (1.8)	50.6 (2.2)	70.5 (1.7)

SOURCE: CDC/NCHS, National Health Interview Survey.

Technical Notes

Findings presented in this report were based on data from the National Health Interview Survey, the National Ambulatory Medical Care Survey, the National Hospital Ambulatory Medical Care Survey, the National Hospital Discharge Survey, and the mortality component of the National Vital Statistics System. Survey descriptions, question wording for estimates, descriptions of statistical analyses, and definitions are provided below.

National Health Interview Survey (NHIS)

Sample design

NHIS is a cross-sectional household interview survey of the U.S. civilian noninstitutionalized population. Data are collected continuously throughout the year in all 50 states and the District of Columbia. NHIS uses a multistage, clustered sample design to produce national estimates for a variety of health indicators (Table). Information on basic health topics is collected for all household members. Interviews are conducted in the home by field staff from the U.S. Census Bureau, using a computer-assisted personal interviewing system, with telephone interviewing permitted for follow-up if necessary. Starting in 2006, the sample design oversampled Asian persons; during 2001–2005, only households with black and Hispanic residents were oversampled. From 2001 to 2009, the final response rate for each survey component (which takes into account household nonresponse) ranged from 81.6% to 88.1% for the family questionnaire, 72.3% to 81.3% for the sample child, and 62.6% to 74.3% for the sample adult. More information is available at: http://www.cdc.gov/nchs/nhis.htm.

Item nonresponse

From 2001 through 2009, item nonresponse for each of the demographic indicators shown in this report was generally less than 1%, with the exception of poverty status, which is based on detailed family income ascertained from the Family Core component of the questionnaire. Because the item nonresponse for the poverty status variable was relatively high (22%–31% from 1997 through 2007), family income data were imputed for families with missing values (5). The denominators for asthma prevalence exclude persons with unknown information about asthma status (less than 0.8% for all years 1997–2009).

National Ambulatory Medical Care Survey (NAMCS)

Sample design

NAMCS is an annual probability survey of nonfederal, office-based physicians providing direct patient care who practice in the 50 states or the District of Columbia, excluding radiologists, anesthesiologists, and pathologists. NAMCS collects data from a national sample of over 2,000 physicians each year who provide information on nearly 30,000 visits. Because persons with multiple visits during the year may be sampled more than once, estimates are for visits, not persons. NAMCS uses a multistage sample design and sampling weights applied to each record to provide nationally representative estimates. Visits to private, nonhospital-based clinics and health maintenance organizations were within the scope of the survey, but visits that occurred in federally operated facilities and hospital-based OPDs were not. A sample of office-based physicians who reported that they were in direct patient care was taken from the master files of the American Medical Association and the American Osteopathic Association. The sample design includes 112 geographic primary sampling units. Within those units, physicians were stratified by specialty, and a sample of physicians was selected. Physicians were randomly assigned to 1 of 52 reporting weeks throughout the year. Between 2005 and 2007, the overall unweighted physician response rate ranged from 58.9% to 61.6%. More information is available at: http://www.cdc.gov/nchs/ahcd.htm.

Item nonresponse

Item nonresponse rates in NAMCS are generally low (5% or less). Sex was imputed for 0.8%–1.6% of records with missing values, and birth year for 1.9%–2.5%, in the survey years 2005–2007. During this period, race was imputed for 20.8%–32.9% of visits and ethnicity for 24.9%–31.0%. In contrast to the imputation method used to impute race and ethnicity in previous years (random assignment of a value from a patient record form with similar characteristics based on physician specialty, geographic region, and three-digit ICD–9–CM code for primary diagnosis), a hierarchical procedure was used in 2006. Cases missing race (or ethnicity) were initially assigned a donor's value after matching donor and recipient by three-digit ICD–9–CM codes for primary diagnosis and ZIP Code of the patient making the sampled visit. If no donor was found after several matching rounds of increasing geographic size (county, state, region), traditional imputation procedures were applied. If both race and ethnicity were missing, both were imputed from the same donor. Standard errors may be underestimated because single imputation was used.

National Hospital Ambulatory Medical Care Survey (NHAMCS)

Sample design

NHAMCS is a national probability sample survey of in-person visits made in the United States to EDs and OPDs of nonfederal short-stay hospitals (hospitals with an average stay of fewer than 30 days) and those whose specialty is general (medical or surgical) or children's general. EDs that operate 24 hours a day are considered within the scope of the ED component; EDs that operate fewer than 24 hours are included in the OPD component of NHAMCS. The hospital sampling frame for 2006 consisted of hospitals listed in the 1991 Verispan Hospital Database (formerly known as the SMG Hospital Database) updated using hospital data

Table. Definitions and questions for NHIS asthma prevalence, school and work absences, and asthma control measures

Estimate	NHIS question	Questionnaire
Asthma period prevalence.	During the past 12 months, did anyone in the family have asthma?	1982–1996 NHIS Respiratory Conditions questionnaires
Current asthma prevalence	Has a doctor or other professional ever told you that [you/your child] had asthma? *and* [Do you/does your child] still have asthma?	2001 forward, NHIS Sample Child and Sample Adult Core questionnaires
Asthma attack prevalence.	Has a doctor or other professional ever told you that [you/your child] had asthma? *and* During the past 12 months, [have you/has your child] had an episode of asthma or an asthma attack?	1997 forward NHIS Sample Child and Sample Adult Core questionnaires
Missed work day	During the past 12 months, how many days were you unable to work because of your asthma?	2008 NHIS Sample Adult Asthma Module questionnaire
Missed school day	During the past 12 months, how many days of [daycare/preschool/school/school or work] did your child miss because of [his/her] asthma?	2008 NHIS Sample Child Asthma Module questionnaire
Taught how to use an inhaler.	Has a health professional shown [you/your child] how to use [your/your child's] inhaler?	2008 NHIS Sample Adult and Sample Child Asthma Module questionnaires
Given an asthma management plan	Has a doctor or other health professional ever given [you/your child] an asthma action plan?	2008 NHIS Sample Adult and Sample Child Asthma Module questionnaires
Taught how to recognize early signs or symptoms of an asthma episode	Has a doctor or other health professional ever taught [you/your child] how to recognize early signs or symptoms of an asthma episode?	2008 NHIS Sample Adult and Sample Child Asthma Module questionnaires
Advised to change things at home, school, or work to improve asthma	Has a doctor or other health professional ever advised you to change things in [your/your child's] home, school, or work to improve [your/your child's] asthma?	2008 NHIS Sample Adult and Sample Child Asthma Module questionnaires
Taught how to respond to an episode of asthma	Has a doctor or other health professional ever taught [you/your child] how to respond to episodes of asthma?	2008 NHIS Sample Adult and Sample Child Asthma Module questionnaires
Activity limitation caused by asthma/breathing problem	This estimate is based on a series of questions on the Family Core questionnaire about limitations in activities of daily living, instrumental activities of daily living, school, work, difficulty walking or remembering, and any other activity limitations: Are [you/your child] limited in any way because of physical, mental, or emotional problems? For persons with a limitation, a question is asked: What conditions or health problems cause [you/your child] limitations? For adults: Lung or breathing problem? For children: Asthma or a breathing problem?	2008 NHIS Person File summary variables based on multiple questions from the Family Core questionnaire. See: ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Survey_Questionnaires/NHIS/2008/English/qfamily.pdf.

SOURCE: CDC/NCHS, National Health Interview Survey (NHIS).

from Verispan, L.L.C. (Yardley, Pennsylvania). About 500 hospitals are included in the sample, from which about 1,200 OPDs and 400 EDs are selected. Because persons with multiple visits during the year may be sampled more than once, estimates are for visits, not persons. NHAMCS uses a multistage probability sample and sampling weights applied to each record to produce nationally representative estimates. Between 2005 and 2007, the overall unweighted hospital response rate ranged from 89.4% to 90.7%. More information is available at: http://www.cdc.gov/nchs/ahcd.htm.

Item nonresponse

Item nonresponse rates in NHAMCS are generally low (5% or less), with some exceptions. Sex was imputed for 0.3%–0.7% of records with missing values, and birth year for 0.7%–1.9%, in the survey years 2005–2007. During this period, race was imputed for 9.8%–14.9% of visits and ethnicity for 17.0%–24.9%. In contrast to imputation methods used in previous years for race and ethnicity (random assignment of a value from a

patient record form with similar characteristics based on physician specialty, geographic region, and three-digit ICD–9–CM code for primary diagnosis), in 2006, cases missing race or ethnicity were initially assigned a donor's value after matching donor and recipient by three-digit ICD–9–CM codes for primary diagnosis and ZIP Code of the patient making the sampled visit; if no donor was found after several matching rounds, imputation procedures based on geographic region, OPD volume by clinic type, and three-digit ICD–9–CM codes for primary diagnosis were applied. If

both race and ethnicity were missing, both were imputed from the same donor. Beginning in 2007, a new method was used to impute race and ethnicity. Race and ethnicity assignments were based, where possible, on diagnosis and patient's locality (ZIP Code or state or county of residence). A hot deck approach (i.e., filling in missing values on incomplete records using values from similar but complete records of the same data set) was employed, rather than the previously used cold deck strategy (i.e., filling in missing values on incomplete records using values from similar but complete records of the data set from the previous year), except in cases where a matching record could not be obtained from the current data. When race or ethnicity data could not be assigned using patient locality, the new method attempted to impute within the same facility wherever possible. Failing that, imputation was based on diagnosis, hospital, type of emergency service area, immediacy, and, as a last resort, on a randomly selected record.

National Hospital Discharge Survey (NHDS)

Sample design

NHDS collects data from a sample of inpatient records acquired from a national sample of hospitals. Because persons with multiple discharges during the year may be sampled more than once, estimates are for discharges, not persons. Only hospitals with an average length of stay of fewer than 30 days for all patients, and general hospitals and children's general hospitals, are included in the survey. Federal, military, and Department of Veterans Affairs hospitals, as well as hospital units of institutions (e.g., prison hospitals), and hospitals with fewer than six beds staffed for patient use are excluded. NHDS collects data from a sample of approximately 270,000 inpatient records acquired from a national sample of about 500 hospitals. A three-stage sampling design procedure is used to produce national estimates of hospital discharges. Weights are assigned to each sample record. Between 2005 and 2007,

the overall unweighted hospital response rate ranged from 88% to 93%. More information is available at: http://www.cdc.gov/nchs/about/major/hdasd/nhds.htm.

Item nonresponse

Less than 1% of records failed to include the sex, age, or date of birth of the patient. If the hospital record did not state either the age or sex of patient, the characteristic was imputed by assigning an age or sex value that maintained the known distribution of these variables according to the categories of the first-listed diagnosis. In a very few cases (less than 1% of the records), the age or sex was edited because it was inconsistent with the diagnosis. For the period 2005–2007, data for race were missing for 28%–30% of the discharges, and no attempt was made to impute for these missing values. Nonresponse for ethnicity is generally higher than for race; therefore, ethnicity was not imputed and is not reported in this analysis.

Mortality component of the National Vital Statistics System (NVSS)

Data are based on information from all death certificates filed in the 50 states and the District of Columbia and are processed by the Centers for Disease Control and Prevention's National Center for Health Statistics (NCHS). Mortality statistics are based on information coded by the states and provided to NCHS through the Vital Statistics Cooperative Program, as well as from copies of original certificates received by NCHS from state registration offices. More information is available at: http://www.cdc.gov/nchs/deaths.htm.

Age adjustment

Data for the percentages shown in Figure 2 and Table 2 were age-adjusted using the 2000 U.S. population provided by the U.S. Census Bureau as the standard population (6). Age adjustment was used to allow comparison among various population subgroups that have

different age composition. The following age groups were used for age adjustment: under 1 year, 1–4 years, 5–14 years, 15–25 years, 25–34 years, 35–44 years, 45–54 years, 55–64 years, 65–74 years, 75–84 years, and 85 years and over.

Estimation of counts

The estimated counts of persons affected by asthma (NHIS), number of office visits for asthma to private physician offices (NAMCS), visits to hospital OPDs (NHAMCS) and EDs (NHAMCS), and asthma hospitalizations (NHDS) are calculated by weighting the number of respondents or visits by the survey weights. Age-adjusted estimates of counts of numbers of persons affected by asthma are not presented because only the crude numbers are of interest.

Tests of significance

Statistical tests performed to assess the significance of differences in estimates were two-tailed, with no adjustments for multiple comparisons. The test statistic used to determine statistical significance of differences between two percentages was

$$Z = \frac{|X_a - X_b|}{\sqrt{S_a^2 + S_b^2}}$$

where X_a and X_b are the two percentages being compared, and S_a and S_b are the standard errors of those percentages. The critical value used for two-sided tests at the 0.05 level of significance was 1.96.

The significance of trends was tested using Joinpoint software (7) to determine whether an apparent change over time was statistically significant, taking into account the standard error for each data point. The weighted least squares regression models produce an annual percentage rate change when a log of the outcome is analyzed.

Relative standard error

Estimates with a relative standard error (RSE) greater than 30% are not reported. The RSE of an estimate is calculated as:

RSE (percent) = $(S_{Est}/Est) * 100$,

where S_{Est} is the standard error of the estimate and Est is the estimate.

Definition of terms

Age—Recorded for each person as of his or her last birthday.

Hispanic or Latino origin—Includes persons of Mexican, Puerto Rican, Cuban, Central and South American, or Spanish origin. Persons of Hispanic or Latino origin may be of any race.

Poverty status—Based on family income and family size, using the U.S. Census Bureau's poverty thresholds. ''Poor'' persons are defined as those with family incomes below the poverty threshold. Persons who are ''near poor'' have family incomes of 100% to less than 200% of the poverty threshold, and persons who are ''not poor'' have family incomes that are 200% of the poverty threshold or above.

Race and Hispanic origin—The collection of race and Hispanic origin data in NHIS, NAMCS, NHAMCS, and NHDS conforms with the 1997 U.S. Office of Management and Budget's *Revisions to the Standards for the Classification of Federal Data on Race and Ethnicity*. The 1997 Standards specify five racial groups as the minimum for data collection on race in federal statistics: American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, and White. The standards also offer respondents the opportunity to select more than one of the five groups. Hispanic or Latino origin includes persons of Mexican, Puerto Rican, Cuban, Central and South American, and other or unknown Latin American or Spanish origin. Persons of Hispanic origin may be of any race. The NVSS mortality component conformed to the 1997 Standards in 21 states in 2005 and increased to 27 states and the District of Columbia in 2007. To provide uniformity and comparability of NVSS mortality data during the transition period, before all or most of the data become available in the new multiple-race format, the responses of those for whom more than one race was reported (multiple race) are bridged to a single race (8).

Suggested citation

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