

The Epidemiology of Asthma During Pregnancy: Prevalence, Diagnosis, and Symptoms

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Asthma is reported to be the most common obstructive pulmonary disease of pregnancy and one of the most common serious medical conditions to complicate pregnancy [1,2]. Trends in asthma prevalence in the United States have increased over the past several decades, particularly among younger age groups, which suggests a concurrent increase in prevalence in the pregnant population [3,4]. We previously demonstrated from U.S. national health surveys that the prevalence of asthma during pregnancy in 1997 to 2001 was between 3.7% (95% CI, 2.7%–4.7%) and 8.4% (95% CI, 7.1%–9.8%) [5].

This article provides an overview of the most current national and international trends in the epidemiology of asthma during pregnancy. We begin by using several recent national health surveys to update our previous estimates of the prevalence of ever having received a diagnosis of asthma by a health professional, and current asthma, among pregnant women and women of child-bearing age in the United States. Trends in these estimates over time are examined, and markers of asthma control are described by population characteristics. A summary of international estimates of asthma in pregnancy is provided.

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We also review some potential problems in the validity of asthma diagnoses and conclude with a description of reported asthma symptoms and medication use in pregnancy from a large ongoing prospective study.

Asthma prevalence

Prevalence of asthma during pregnancy in the United States

Data sources

The National Health Interview Survey (NHIS) is a cross-sectional survey, which is planned and conducted in conjunction with the U.S. Bureau of the Census. Since its inception in 1957, the NHIS has been the primary source of general health information on the civilian, noninstitutionalized population of the United States, and the primary source of asthma prevalence data in the non-pregnant population of the United States [6]. A 1997 survey redesign added questions about asthma that inquired explicitly about physician-diagnosed asthma, asthma attacks in the past 12 months, and visits to an emergency room or urgent care center because of asthma in the past 12 months. Women 18 to 49 years of age were asked about their current pregnancy status. In 2001, a question about current asthma was added that allows comparability to other national surveys that inquire about asthma. In 2003, the response rate for total households was 89.2% and for adults was 77.3%.

The National Health and Nutrition Examination Survey (NHANES), administered by the National Center for Health Statistics (NCHS), is a national probability sample of the civilian, noninstitutionalized population of the United States. In addition to a home interview, NHANES includes medical and dental examinations, physiologic measurements, and laboratory tests performed by trained medical personnel in Mobile Examination Centers [7]. Beginning in 1999, NHANES became a continuous, annual survey rather than a periodic survey. Survey data are released every 2 years for public use. The overall response rate for NHANES II (1976–1980) was 73% and for NHANES III (1988–1994) was 79% [7,8]. For 1999–2000, the overall interview response rate was 82% and the examined response rate was 78%.

The Behavioral Risk Factor Surveillance System (BRFSS), a collaboration between the Centers for Disease Control and Prevention and U.S. states and territories, is a random-digit-dialed telephone survey of one adult per household that has collected uniform, state-specific data of the adult population 18 years of age or older since 1984 [9]. Poststratification adjustment of BRFSS data, which forces the sum of the weighted frequencies to equal population estimates for each region or state, enables nationally representative estimates to be produced. By 1996, 50 states, the District of Columbia, Puerto Rico, and the Virgin Islands were participating in BRFSS. In 2000, questions about pregnancy and asthma were added to the core component of the questionnaire [10]. In 2003, the median

survey response rate among U.S. states and territories was 53.2% (ranging from 34.4% in New Jersey to 80.5% in Puerto Rico) [11].

Assessment of pregnancy and asthma

Table 1 describes the questions on pregnancy and asthma from the 2001–2003 NHIS, 2000–2003 BRFSS, NHANES III (1988–1994), 1999–2000 NHANES, and 2001–2002 NHANES. Because of an unusually low response rate to the question about current asthma in the 1999–2000 NHANES, most of the analyses that involve NHANES focus on the 2001–2002 NHANES. Markers of asthma control, including asthma attacks and asthma-related emergency visits, were evaluated from the 1997–2003 NHIS. Asthma attacks were assessed among those who reported an asthma diagnosis with the question, “During the past 12 months, have you had an episode of asthma or asthma attack?”. Among those who reported an asthma attack, asthma-related emergency visits were considered with, “During the past 12 months, have you had to visit an emergency room or urgent care center because of asthma?”.

Data analysis

In our analysis, women of childbearing age were defined as 18 to 44 years of age. Women who were unsure or refused to answer the questions about their asthma were excluded from all analyses; women who were unsure or refused to answer the questions about pregnancy were excluded from analyses of pregnant women.

To increase comparability between surveys, weighted state-specific BRFSS data were aggregated and subsetting to exclude Puerto Rico, Guam, and the Virgin Islands. Data from multiple years were combined to increase the precision of estimates. Estimated numbers of U.S. women and prevalence rates with 95% confidence intervals were calculated from the 2000–2003 BRFSS and 2001–2003 NHIS for ever having received an asthma diagnosis and current asthma among pregnant women and women of childbearing age. Trends over time among women of childbearing age were examined using NHANES II, NHANES III, and the 2001–2002 NHANES. Because of small numbers among population subgroups, data were combined from the 1997 to 2003 NHIS surveys to describe asthma control by various demographic characteristics. Prevalence estimates for asthma attacks and asthma-related emergency visits were calculated. Weighted prevalence estimates and standard errors for all datasets were calculated using SUDAAN, a statistical software package that is used to account for the complex survey design and to adjust for selection probability, oversampling, and non-response. In keeping with NCHS standards, estimates were considered statistically unreliable and not reported if the relative standard was greater than 30%. All analyses were performed using SAS Version 9.1 (SAS Institute, Cary, North Carolina) and SUDAAN Release 9.0 (RTI, Chapel Hill, North Carolina).

Estimates of asthma prevalence

We derived estimates of the prevalence of asthma in pregnant and all childbearing-aged women from the following unweighted numbers of women 18 to

Table 1
Comparison of Centers for Disease Control and Prevention and National Center for Health Statistics surveys for estimation of the prevalence of asthma during pregnancy

Survey	Years	Pregnancy measurement	Asthma measurement
National Health Interview Survey	1957–2003 ^a (2003: N=30,852)	1997–2003: “Are you currently pregnant?” (Women 18–49 years)	1957–1967: “Now I’m going to read a list of conditions—Please tell me if you, your ____, etc., have had any of these conditions during the past 12 months? Asthma?” 1970:
			“Now I’m going to read a list of conditions; During the past 12 months, did anyone in the family have any of these conditions—...Asthma?” and “Who was this?” 1978–1996: “During the past 12 months, did anyone in the family have—...Asthma?” and “Who was this?” 1997–2000: “Have you ever been told by a doctor or other health professional that you have asthma?” and “During the past 12 months, have you had an episode of asthma or asthma attack?” 2001–2003: “Have you ever been told by a doctor or other health professional that you have asthma?” and “Do you still have asthma?”

National Health and Nutrition Examination Survey (NHANES)	NHANES I: 1970–1975 (N=31,973)	1970–1975, 1976–1980: “Are you pregnant now?”	1970–1975: “Has a doctor ever told you that you have had any of the following conditions: asthma?” and “Do you still have it?”
	NHANES II: 1976–1980 (N=27,801)	1988–1994: “Have you ever been pregnant?” and “Are you now pregnant?” + positive urine pregnancy test (20–59 years)	1976–1980: “Did a doctor ever tell you that you had any of the following conditions, and if so, do you still have it? ...Asthma? Still have it?”
	NHANES III: 1988–1994 (N=39,695)	1999–2002: “Have you ever been pregnant?” and “Do you think you are pregnant now?” + positive urine pregnancy test (Women 15–49 years [1999–2000]; Women 12–60 [2001–2002])	1988–1994: “Has a doctor ever told you that you had asthma?” and “Do you still have asthma?”
	NHANES 1999–2000 (N=9,965)		1999–2002: “Have you ever been told by a doctor or other health professional that you have asthma?” and “Do you still have asthma?”
Behavioral Risk Factor Surveillance System	NHANES 2001–2002 (N=11,039)		2000–2003: “Did a doctor ever tell you that you had asthma?” and “Do you still have asthma?”
	1994–2003 ^a (2001: N=264,684)	“To your knowledge, are you now pregnant?” (Women 18–44 years with intact cervix)	2001–2003: “Have you ever been told by a doctor, nurse, or other health professional that you had asthma?” and “Do you still have asthma?”

^a Data available annually for this period.

44 years of age: 233,161 in the 2000–2001 BRFSS, 64,564 in the 1997–2003 NHIS, and 1622 in the 2001–2002 NHANES. The weighted proportion of current pregnancy among all women aged 18 to 44 ranged from 4.4% in the 2001–2003 NHIS to 8.7% in the 2001–2002 NHANES.

As shown in Table 2, the number of women 18 to 44 years of age who ever received a diagnosis of asthma from a health professional in the United States is estimated to range between 6.8 and 7.4 million—12.3% (95% CI, 11.9%–12.8%) and 13.7% (95% CI, 13.4%–13.9%) of childbearing-aged women in the 2001–2003 NHIS and the 2000–2003 BRFSS, respectively. Among pregnant women 18 to 44 years of age, approximately 233,607 to 300,151 women, or 12.4% (95% CI; 11.2%–13.8%) of pregnant women in the 2000–2003 BRFSS and 12.6% (95% CI, 10.4%–15.2%) of pregnant women in the 2001–2003 NHIS have received a diagnosis of asthma. Age-specific rates of ever having received a diagnosis are slightly lower among pregnant women 25 to 44 years of age compared with all childbearing-aged women 25 to 44 years of age, but are comparable or slightly higher among pregnant women 18 to 24 years of age compared with all childbearing-aged women 18 to 24 years of age.

Table 2 also describes the prevalence of current asthma among women 18 to 44 years of age. An estimated 4.6 to 5.1 million women in the United States annually, or 8.4% (95% CI, 8.0%–8.8%) and 9.5% (95% CI, 9.3%–9.7%) of childbearing-aged women in the 2001–2003 NHIS and the 2000–2003 BRFSS, respectively, reported current asthma. Among pregnant women 18 to 44 years of age, 157,648 to 209,396 women, or 8.4% (95% CI, 7.4%–9.5%) of pregnant women in the 2000–2003 BRFSS and 8.8% (95% CI, 7.0%–11.0%) of pregnant women in the 2001–2003 NHIS, had current asthma. Age-specific rates of current asthma are lower among pregnant women 25 to 44 years of age compared with all childbearing-aged women 25 to 44 years of age, but are comparable or slightly higher among pregnant women 18 to 24 years of age compared with all childbearing-aged women 18 to 24 years of age. Among women 18 to 24 years of age, 12.2% (95% CI, 9.9%–14.9%) and 12.3% (95% CI, 8.6%–17.3%) of pregnant women in the 2000–2003 BRFSS and the 2001–2003 NHIS, respectively, reported current asthma.

A slightly higher estimate (14.7%; 95% CI, 8.0%–25.6%) of pregnant woman who ever had received a diagnosis of asthma came from the 2001–2002 NHANES (Table 3). The results from the 1999–2000 NHANES are slightly higher, although the confidence intervals are wide and overlap between 1999–2000 and 2001–2002. We were unable to estimate current asthma among pregnant women from the 2001–2002 NHANES because of the small sample size.

Trends in asthma prevalence over time

Trends over time in asthma prevalence among women of childbearing age (18–44 years of age) were analyzed using NHANES II, NHANES III, and 2001–2002 NHANES, and among pregnant women using NHANES III and 2001–2002 NHANES (see Table 3). As reported previously [5], between 1976 to 1980 and 1988 to 1994, the prevalence of ever having received a diagnosis of asthma

Table 2
Estimated annual asthma prevalence among pregnant and childbearing-aged women, 18 to 44 years of age—United States^a, Behavioral Risk Factor Surveillance System, National Health Interview Survey, 2000–2003

	All women			Pregnant ^b women			Current asthma		
	Asthma diagnosis, ever ^c			Asthma diagnosis, ever					
	N ^e	%	95% CI	N	%	95% CI	N	%	95% CI
BRFSS, 2000–2003									
Total	7,366,349	13.7	13.4–13.9	233,606	12.4	11.2–13.8	157,649	8.4	7.4–9.5
Age (y)									
18–24	2,093,504	16.0	15.4–16.6	113,270	17.3	14.6–20.3	79,671	12.2	9.9–14.9
25–34	2,503,808	13.3	12.9–13.6	99,421	10.2	8.9–11.6	64,768	6.7	5.7–7.8
35–44	2,769,037	12.6	12.3–13.0	20,915	8.3	5.8–11.8	13,210	5.3	3.5–7.8
NHIS, 2001–2003									
Total	6,808,207	12.3	11.9–12.8	300,151	12.6	10.4–15.2	209,396	8.8	7.0–11.0
Age (y)									
18–24	1,960,531	14.3	13.2–15.5	121,408	14.9	10.9–20.1	99,644	12.3	8.6–17.3
25–34	2,293,586	12.0	11.3–12.8	135,596	10.9	8.3–14.3	86,359	7.0	5.0–9.6
35–44	2,554,090	11.4	10.7–12.1	43,147	13.2	8.5–19.9	23,393	7.1	4.0–12.5

^a Includes the 50 states and the District of Columbia.

^b Answering “yes” to “To your knowledge, are you now pregnant?” (BRFSS, 2000–2003) or “Are you currently pregnant?” (NHIS, 2001–2003).

^c Answering “yes” to “Did a doctor ever tell you that you had asthma?” (BRFSS, 2000), or “Have you ever been told by a doctor, nurse, or other health professional that you had asthma?” (BRFSS, 2001–2003), or “Have you ever been told by a doctor or other health professional that you have asthma?” (NHIS, 2001–2003).

^d Answering “yes” to “Do you still have asthma?” (BRFSS, 2000–2003 and NHIS, 2001–2003).

^e Estimated annual number for the United States.

Table 3
Estimated annual asthma prevalence among pregnant and childbearing-aged women, 18 to 44 years of age—United States^a, National Health and Nutrition Examination Survey, 1976–2002

	All women				Pregnant ^b women			
	Asthma diagnosis, ever ^c		Current asthma ^d		Asthma diagnosis, ever		Current asthma	
	N ^e	%	95% CI	N	%	95% CI	N	95% CI
1976–1980								
Total	2,617,268	6.0	4.6–7.4	1,262,827	2.9	2.0–3.8	— ^f	—
Age (y)								
18–24	670,658	4.7	3.5–5.9	262,020	1.8	0.9–2.7	—	—
25–34	1,100,326	6.6	4.4–8.7	568,924	3.4	1.9–4.9	—	—
35–44	846,284	6.9	4.7–9.1	431,883	3.5	2.1–5.0	—	—
1988–1994								
Total	4,175,236	7.6	6.7–8.6	3,128,966	5.7	4.8–6.7	201,557	6.6 2.7–10.4 98,580 3.2 1.6–4.9
Age (y)								
18–24	1,001,649	7.6	5.4–9.7	795,093	6.0	4.0–8.0	—	—
25–34	1,546,868	7.5	5.5–9.6	1,236,343	6.0	4.0–8.0	—	—
35–44	1,626,719	7.8	6.3–9.2	1,097,530	5.3	4.0–6.5	—	—
1999–2000								
Total	8,643,055	15.1	12.0–19.0	— ^g	749,757	16.2	9.8–25.7	—
Age (y)								
18–24	2,212,721	15.7	10.3–23.4	—	—	—	—	—
25–34	3,376,912	16.2	12.2–21.2	—	316,245	12.0	8.1–17.5	—
35–44	3,053,422	13.8	11.1–17.0	—	—	—	—	—

2001–2002									
Total	8,621,412	15.2	11.7–19.5	5,117,307	9.0	6.6–12.2	680,871	14.7	8.0–25.6
Age (y)									
18–24	2,251,525	15.6	10.4–22.9	1,301,635	9.0	5.7–14.1	—	—	—
25–34	2,964,937	14.3	9.2–21.4	1,839,723	8.9	4.6–16.3	—	—	—
35–44	3,404,950	15.7	12.2–20.1	1,975,949	9.2	6.6–12.6	—	—	—

^a Includes the 50 states.

^b Answering “yes” to “Are you pregnant now?” (1976–1980), or “yes” to “Have you ever been pregnant?” and “Are you now pregnant?” + positive urine pregnancy test (1988–1994), or “yes” to “Are you currently pregnant?” or a positive urine pregnancy test (2001–2002).

^c Answering “yes, still have it,” “yes, does not still have it,” “yes, blank but applicable,” or “yes, don’t know if still have it” to “Did a doctor ever tell you that you had any of the following conditions, and if so, do you still have it?” (1976–1980), or “yes” to “Has a doctor ever told you that you had asthma?” (1988–1994), or “yes” to the question, “Have you ever been told by a doctor or other health professional that you had asthma?” (2001–2002).

^d Answering “yes, still have it” to “Did a doctor ever tell you that you had any of the following conditions, and if so, do you still have it?” (1976–1980), or “yes” to the questions, “Has a doctor ever told you that you had asthma?” and “Do you still have asthma?” (1988–1994), or “yes” to the questions, “Have you ever been told by a doctor or other health professional that you had asthma?” and “Do you still have asthma?” (2001–2002).

^e Estimated annual number for the United States.

^f Too few observations to calculate reliable estimates.

^g Estimate seems to be unreliable because of unusually low response to question “Do you still have asthma?” in the 1999–2000 survey cycle.

Table 4
Estimated annual prevalence of asthma control characteristics among pregnant and childbearing-aged women, 18 to 44 years of age—United States^a, National Health Interview Survey, 1997–2003

	All women				Pregnant ^b women			
	Asthma attack ^c		ED visit ^d		Asthma attack		ED visit	
	%	95% CI	%	95% CI	%	95% CI	%	95% CI
Total	5.0	4.8–5.3	1.4	1.3–1.5	4.1	3.4–5.1	1.6	1.2–2.2
Age (y)								
18–24	5.4	5.0–5.9	1.7	1.4–2.0	5.4	3.9–7.5	1.9	1.2–3.0
25–34	4.9	4.6–5.3	1.4	1.2–1.6	3.5	2.5–4.8	1.5	0.9–2.5
35–44	4.9	4.6–5.2	1.3	1.1–1.4	3.4	1.9–5.9	— ^e	
Marital status								
Married	4.2	4.0–4.5	1.0	0.9–1.1	3.1	2.4–4.0	1.2	0.7–1.9
Unmarried	6.0	5.7–6.4	1.9	1.8–2.2	7.1	5.0–10.0	2.8	1.8–4.3
Family income								
<\$20,000	6.5	6.1–6.9	2.4	2.2–2.7	5.6	4.0–7.7	2.5	1.6–3.9
≥\$20,000	4.7	4.5–5.0	1.2	1.0–1.3	3.9	3.0–5.1	1.5	0.9–2.2
Race/ethnicity								
Hispanic or Latino ^f	4.5	4.1–4.9	1.2	1.0–1.4	3.9	2.7–5.8	2.1	1.3–3.5
Puerto Rican	10.9	9.2–12.9	4.8	3.7–6.3	18.2	9.9–31.2	—	
Mexican	1.8	1.3–2.4	0.6	0.4–1.0	—		—	
Mexican American	2.8	2.2–3.6	0.9	0.6–1.3	—		—	
Other Hispanic	3.6	3.0–4.3	1.2	0.9–1.5	—		—	

Black, non-Hispanic	4.6	4.2-5.1	1.9	1.6-2.3	4.1	2.4-7.1	—
White, non-Hispanic	5.4	5.2-5.7	1.4	1.3-1.6	4.5	3.4-5.9	1.4
Other, non-Hispanic ^g	3.4	2.7-4.2	0.8	0.5-1.3	—	—	0.9-2.3
Region ^h							
Northeast	5.5	5.0-5.9	1.8	1.5-2.1	6.4	4.3-9.2	3.1
Midwest	5.5	5.1-5.9	1.4	1.2-1.6	3.7	2.4-5.4	—
South	4.4	4.1-4.8	1.2	1.1-1.4	4.3	3.0-6.3	1.8
West	5.3	4.8-5.8	1.4	1.2-1.6	2.7	1.6-4.3	—

Abbreviation: ED, emergency department.

^a Includes the 50 states and the District of Columbia.

^b Answering "yes" to "Are you currently pregnant?"

^c Answering "yes" to "Have you ever been told by a doctor or other health professional that you have asthma?" and "During the past 12 months, have you had an episode of asthma or asthma attack?"

^d Answering "yes" to "Have you ever been told by a doctor or other health professional that you have asthma?"

^e Estimate considered unreliable because relative standard error >30%.

^f Women of Hispanic or Latino origin may be of any race or combination of races.

^g Includes other race or combination of races.

^h Northeast = Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont; Midwest = Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin; South = Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia; and West = Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

increased from 6.0% (95% CI, 4.2%–7.9%) to 7.6% (95% CI, 5.7%–9.5%) among women of childbearing age, whereas the prevalence of current asthma doubled from 2.9% (95% CI, 1.6%–4.2%) to 5.7% (95% CI, 4.8%–6.7%). Among the youngest age group (18–24 years of age), the prevalence of current asthma more than tripled from 1.8% (95% CI, 0.9%–2.7%) to 6.0% (95% CI, 4.0%–8.0%). Between 1988 to 1994 and 2001 to 2002, the prevalence of ever having received a diagnosis of asthma doubled to 15.2% (95% CI, 11.7%–19.5%), whereas the prevalence of current asthma increased to 9.0% (95% CI, 6.6%–12.2%).

Among pregnant women, between 1988 to 1994 and 2001 to 2002, the prevalence of ever having received a diagnosis of asthma more than doubled from 6.6% (95% CI, 2.7%–10.4%) to 14.7% (95% CI, 8.0%–25.6%) (see Table 3). We were unable to assess trends in current asthma over time in pregnant women because of the small sample size of the 2001–2002 NHANES.

Estimates of asthma control during pregnancy

As demonstrated in Table 4, the estimated annual prevalence of self-reported asthma attacks by pregnant women in the United States is 4.1% (95% CI, 3.4%–5.1%). Thus, an estimated 98,164 of 254,970, or 38.5% (95% CI, 32.2%–45.3%) of pregnant women with an asthma diagnosis in the United States reported having experienced at least one asthma attack in the previous year. The prevalence of asthma attacks seems to be elevated among pregnant women who are younger, unmarried, or have a lower annual family income. Puerto Rican women, in particular, are much more likely than other Hispanic subgroups or racial/ethnic groups to report an asthma attack in the previous year. As Figs. 1 through 5 demonstrate, however, the effect of race/ethnicity differs by marital status and income; unmarried and lower income white, non-Hispanic women who are preg-

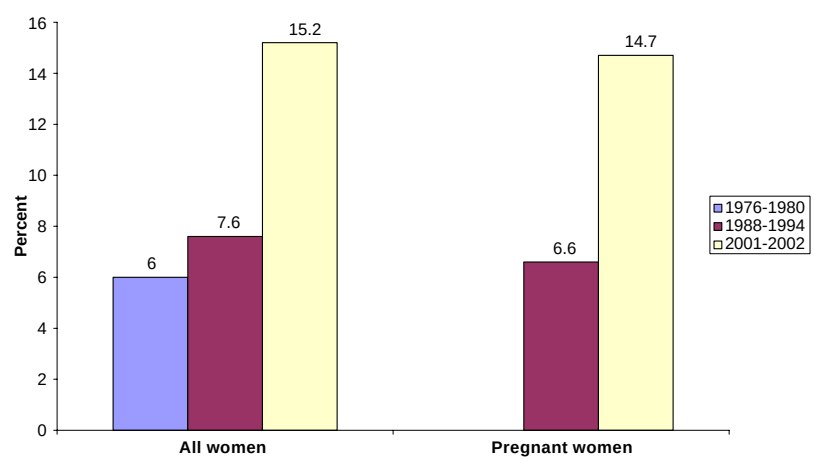


Fig. 1. Trends over time in asthma prevalence among pregnant and childbearing-age women, 18–24 years of age—United States, National Health and Nutrition Examination Survey.

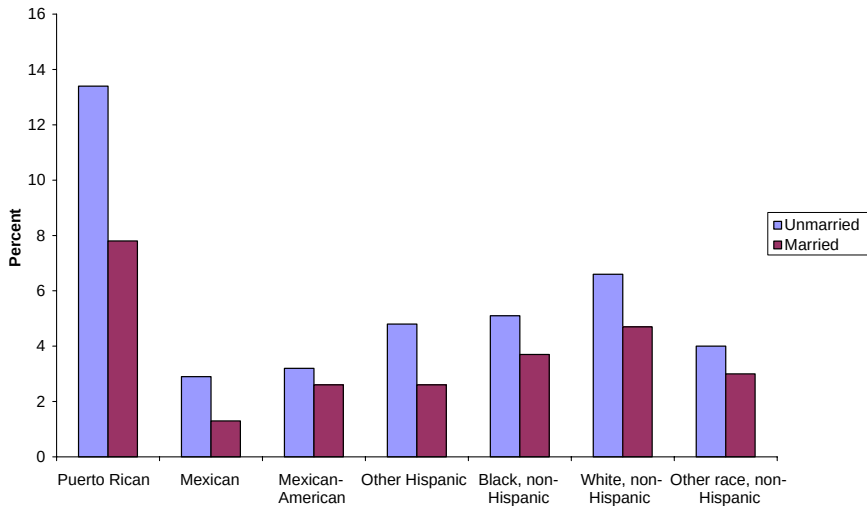


Fig. 2. Asthma attack prevalence among childbearing-age women, 18–24 years of age by race/ethnicity and marital status—United States, National Health Interview Survey, 1997–2003.

nant have a higher prevalence of asthma attacks than do pregnant Hispanics overall. In addition, the prevalence of asthma attacks among married pregnant women (3.1%; 95% CI, 2.4%–4.0%) is slightly lower than the rate among married childbearing-aged women overall, whereas the attack prevalence of 7.1% (95% CI, 5.0%–10.0%) is slightly higher. There seems to be some variation in the asthma attack prevalence by geographic region of residence within the United States.

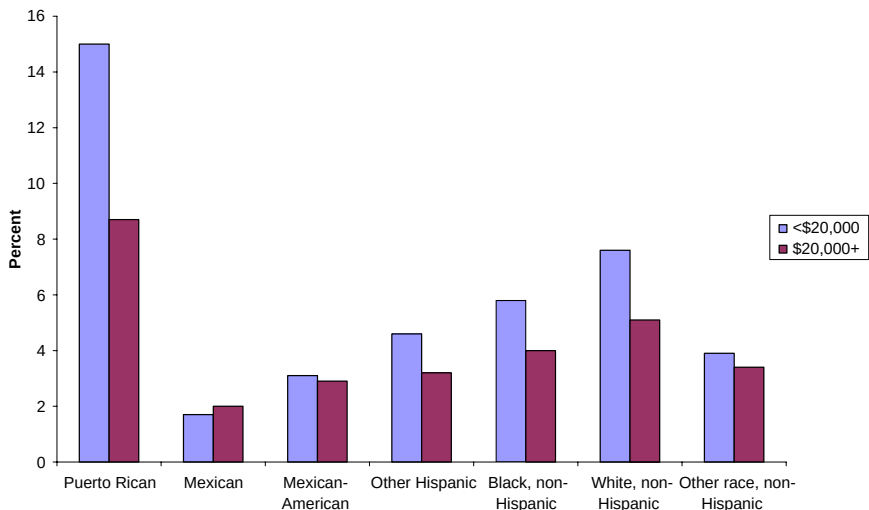


Fig. 3. Asthma attack prevalence among childbearing-age women, 18–24 years of age by race/ethnicity and family income—United States, National Health Interview Survey, 1997–2003.

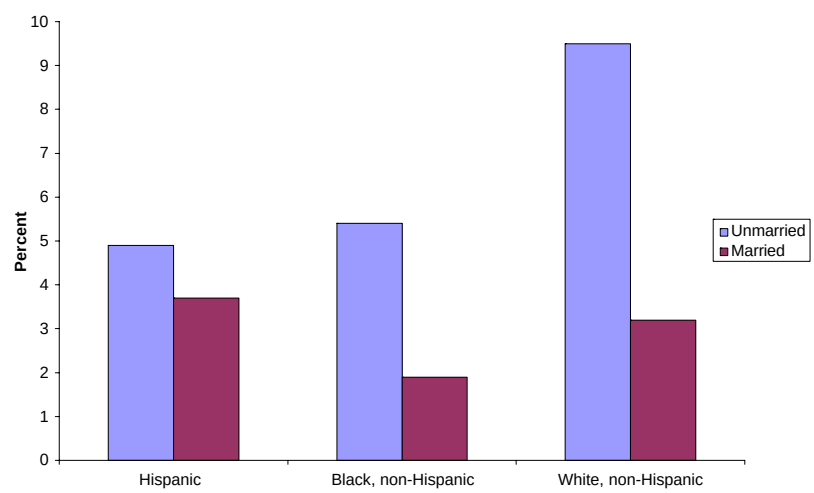


Fig. 4. Asthma attack prevalence among childbearing-age women, 18–24 years of age by race/ethnicity and marital status—United States, National Health Interview Survey, 1997–2003.

Table 4 also shows that the estimated annual prevalence of self-reported emergency visits for asthma by pregnant women in the United States is 1.6% (95% CI, 1.2%–2.2%). Thus, an estimated 37,990 of 98,164, or 38.7% (95% CI, 28.9%–49.5%) of pregnant women who have experienced at least one asthma attack in the previous year report having had to visit an emergency room or urgent care center because of asthma during that year. The prevalence of asthma emergency visits seems to be elevated among pregnant women who are younger,

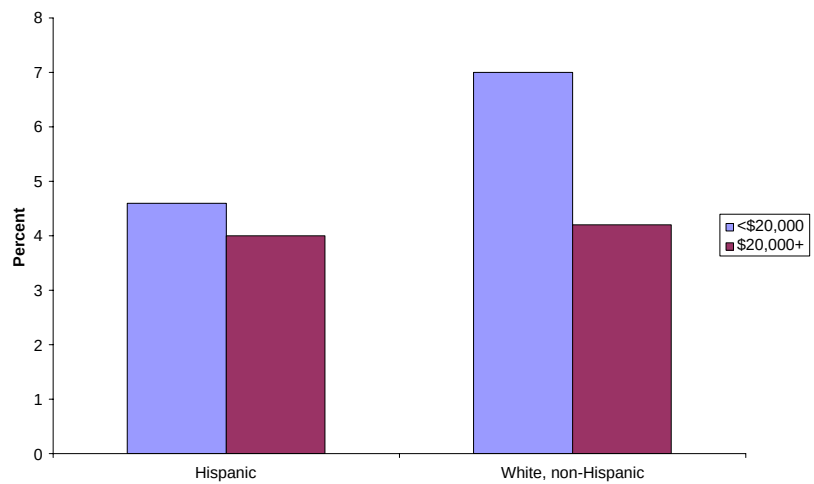


Fig. 5. Asthma attack prevalence among pregnant women, 18–24 years of age by race/ethnicity and family income—United States, National Health Interview Survey, 1997–2003.

unmarried, of lower income status, of Hispanic or Latino heritage, or live in the northeast United States.

Prevalence of asthma during pregnancy internationally

We assessed recent international reports of asthma in pregnancy. An electronic search was conducted with MEDLINE/PUBMED (1990 to August 2005) using the search strategy: asthma and (pregnancy or pregnant). Studies were included that assessed whether pregnant or recently delivered women had ever had asthma or currently had asthma. Studies were not excluded on the basis of language or on the basis of providing a nationally representative sample. Results are summarized in Table 5 [12–22]. Estimates of current asthma during pregnancy ranged from 0.4% from hospital discharge data that were collected for administrative purposes in Canada between 1989 and 1996, to 12.4% of pregnant women in Western Australia, where asthma prevalence in the general population is much higher. Differences in definitions of asthma, time periods, and populations assessed may have contributed to the wide geographic variation that was observed. International studies of children and adults using standardized definitions for assessing asthma within a shared time frame demonstrated striking differences in asthma prevalence throughout the world [23,24]. Differences in genetic, social, environmental, and health care context that are experienced by pregnant women across settings also may contribute to international variations in the prevalence of asthma during pregnancy.

Conclusions on prevalence

Data from the most recent U.S. national health surveys demonstrate that the prevalence of current asthma during pregnancy is between 8.4% (BRFSS, 95% CI; 7.4%–9.5%) and 8.8% (NHIS, 95% CI, 7.0%–11.0%). The prevalence seems to be increasing, as indicated by increasing prevalence among younger pregnant women in these data, as well as increasing trends over time in women of childbearing age in NHANES. The addition of a question about current asthma to the 2001 NHIS allowed us to estimate the prevalence of asthma in a comparable manner to the BRFSS and to consider asthma attack prevalence separately, as a marker of asthma control.

The estimated annual prevalence of self-reported asthma attacks by pregnant women in the United States is 4.1% (95% CI, 3.4%–5.1%). Hence, an estimated 98,164 of 254,970, or 38.5% (95% CI; 32.2%–45.3%) of pregnant women with an asthma diagnosis in the United States report having experienced at least one asthma attack in the previous year. An estimated 37,990 of 98,164, or 38.7% (95% CI; 28.9%–49.5%) of pregnant women who experienced at least one asthma attack in the previous year report having had to visit an emergency room or urgent care center because of asthma during that year. Thus, a substantial portion of pregnant asthmatics seem to be experiencing significant asthma-related morbidity.

Table 5
International estimations of the prevalence of asthma during pregnancy

Author, year, country	Study design	Participants	Asthma measurement	Results
Alexander et al, 1998 [12], Canada	Retrospective cohort	All women residing in Halifax County, Nova Scotia, who delivered at Grace Maternity Hospital between January 1, 1991 and December 31, 1993 (N=14,565)	Current asthma identified from perinatal database using a diagnostic code for asthma	5.6% current asthma (increase from 4.8% in 1991 to 6.9% in 1993)
Kurineczuk et al, 1999 [13], Australia	Cross-sectional	Ten percent random sample of recently delivered Western Australian mothers selected from the Midwives' Notification of Birth Forms received by the Health Department of Western Australia who delivered between January 1 and April 16, 1995, surveyed by postal questionnaire (N=635)	Ever asthma: ever having had three or more attacks of wheezing at any stage in life provided that the attacks did not occur only in the first year of life Current asthma: having been told by a doctor that they had asthma and the asthma was reported as still continuing, or having had an attack of wheezing or asthma in the past year (ie, during their pregnancy)	21.3% ever asthma, 12.4% current asthma, 8.8% asthma attack or wheezing during pregnancy
Ellegård et al, 2000 [14], Sweden	Prospective cohort	Pregnant women at their first visit at five antenatal care centers in the southern part of a Swedish county (N=599)	Self-reported asthma recorded by an interviewing midwife during first prenatal visit	6.5% current asthma
Källén et al, 2000 [15], Sweden	Retrospective cohort	Women in the Swedish Medical Birth Registry of births from all delivery units in Sweden between 1984 and 1995 (N=36,985)	Self-reported asthma recorded by an interviewing midwife during first prenatal visit and ever having been hospitalized for asthma (from hospital discharge register)	3.8% current asthma
Wén et al, 2001 [16], Canada	Retrospective cohort	Women admitted to the hospital for obstetric delivery as reported by the Canadian Institute for Health for 1989–1990 to 1995–1996 (N=2,017,553)	Current asthma defined as having a discharge diagnosis of asthma (ICD-9 code of 493) in any of the first eight diagnosis fields	0.43% current asthma

Pereira et al, 2002 [17], Mexico	Case series	All pregnant adolescents (≤ 16 y old) who attended the Coordination for the Attention of the Teenage Patient of the National Perinatology Institute who delivered between June 1998 and May 1999 (N=296)	History of asthma from chart review	2.5% ever asthma
Bager et al, 2003 [18], Denmark	Prospective cohort	Singleton women born in Denmark between 1973–1977 (aged 20 to 28 y) recruited during their first prenatal visit with their general practitioners as part of the Danish National Birth Cohort Study and interviewed between 1997 and 2000 (N=9,722)	Ever asthma: ever had asthma and, if so, whether it had been diagnosed by a doctor Current asthma: ever asthma and reported that they still had asthma	11.4% ever asthma, 6.6% current asthma
Karmaus and Eneli, 2003 [19], Germany	Cross-sectional	Pregnant women admitted to maternity wards in six regions in Germany as part of the European Studies on Infertility and Subfecundity (N=1318)	Self-reported doctor-diagnosed asthma	2.5% ever asthma
Frey et al, 2004 [20], Switzerland	Prospective cohort	Women recruited from two maternity hospitals in Berne, Switzerland, interviewed a few days after birth (N=105)	Self-reported doctor-diagnosed asthma	13% ever asthma
Miyake et al, 2005 [21], Japan	Cross-sectional	Pregnant women from Negyagawa and other municipalities recruited for the baseline survey of the Osaka Maternal and Child Health Study between November 1, 2001 and March 31, 2003 (N=1,002)	Asthma after the age of 18: any asthma medication use after 18 y of age Current asthma: any asthma drug use in the previous 12 mo	4.7% asthma after age 18, 2.1% current asthma
Westergaard et al, 2005 [22], Denmark	Cross-sectional	Pregnant women in the Danish National Birth Cohort from September 29, 1997 to March 14, 2000 (N=31,145).	Ever asthma: ever had asthma and, if so, whether it had been diagnosed by a doctor	8.4% ever asthma

Abbreviation: ICD-9, International Classification of Diseases, Ninth Revision.

We found that this burden did not seem to be shared evenly across population subgroups. The prevalence of asthma attacks and asthma-related emergency visits was elevated among pregnant women who were younger, unmarried, of lower income, or of Puerto Rican or non-Hispanic black background (in the case of asthma-related emergency visits). We were unable to sort out the complex relationships between race/ethnicity and socioeconomic status and health care use behavior, or to demonstrate whether the effects of a characteristic (eg, marital status) reflects the influence of access to material resources, socioeconomic position, the presence or absence of social support, or other factors.

Despite the paucity of international data on asthma in pregnancy and the lack of consistency in study design and measurement of asthma between studies, we were able to demonstrate some of the international variation in asthma prevalence. Further work with nationally representative data is needed to characterize better the international trends in asthma during pregnancy.

Understanding national and international epidemiologic trends in asthma during pregnancy is relevant to the clinician and researcher. Continued developments in the epidemiology of asthma during pregnancy will provide the context for further understanding of disease etiology as well as improvement in the prevention and management of this widely prevalent condition. Refer to [Box 1](#) for a summary of asthma prevalence.

Box 1. Summary: asthma prevalence

Asthma was estimated to affect between 157,648 and 209,396 pregnant women in 2000 to 2003, or approximately 8.4% to 8.8% of pregnant women in the United States.

Between 1988 to 1994 and 2001 to 2002, the prevalence of ever having been diagnosed with asthma among pregnant U.S. women increased from 6.6% to 14.7%.

Approximately 4.1% of pregnant women in the United States report having had an asthma attack in the previous year.

A substantial proportion of pregnant women with an asthma diagnosis, 38.5%, report having had an asthma attack in the previous year, and 38.7% of women with an asthma attack report having had to visit an emergency room or urgent care center because of their asthma.

Pregnant women who were younger, unmarried, of lower income, Puerto Rican, or lived in the northeast United States experienced more asthma attacks or asthma-related emergency visits during the previous year.

International studies demonstrate wide variations in asthma prevalence during pregnancy; further characterization of international trends is needed.

Asthma diagnosis

How valid are survey data on asthma prevalence?

Survey prevalence data are heavily dependent on the diagnosis of asthma by a doctor or health professional (see [Table 1](#)). Other studies that use chart review, administrative databases, or medical records also frequently depend on clinical diagnoses and other information that requires an encounter with the health care system. We are unaware of specific studies that examined diagnostic validity in pregnant women; however, it is likely that issues in diagnosing asthma in non-pregnant women are similar and are reviewed briefly below.

Underdiagnosis of asthma

Prevalence of asthma is estimated from national surveys in which women are asked, “Have you *ever* been told by a doctor or other health professional that you have asthma?” (emphasis added). The accuracy of these estimates relies on the validity of the asthma diagnosis at any point in the subject’s life, but particularly during childhood; the validity and reliability of asthma diagnosis in the community; and whether the diagnosis was communicated to, and understood by, the patient. Rather than taking these factors into account, investigations of underdiagnosis of asthma usually compare asthma symptoms that are reported on questionnaires with reports of diagnosis on the same questionnaire.

There has been concern that minority children and children in poverty may be less likely to be diagnosed with asthma because of the lack of access to appropriate health care. Akinbami and colleagues [25] examined this possible bias in the National Health Interview Survey. The analysis included children ages 3 to 17 years. Among children who wheezed in the past 12 months, minority children were more likely to have an asthma diagnosis. After controlling for severity of symptoms, 56.9% of white children who wheezed had an asthma diagnosis, compared with 70.5% of black non-Hispanic children, 82.8% of Puerto Rican children, and 65.4% of Mexican children. Similarly, children from low-income families who wheezed were more likely to be diagnosed than were those from middle income families.

The relationship of asthma diagnosis in children to socioeconomic status also was investigated in Sheffield, United Kingdom [26]. A survey was conducted of all 8- and 9-year-old school children using the International Study of Asthma and Allergies in Children (ISAAC) questionnaire. Social deprivation was based on postal code and divided into quintiles. Among 637 children who reported “significant asthma symptoms,” 383 (60.1%) reported no physician diagnosis; this proportion did not vary across social status. Asthma symptoms were more prevalent among more socially deprived children, and asthma medication use in the absence of physician diagnosis was more prevalent among the more socially advantaged, which suggested some bias in the labeling of asthma.

Some investigators also identified gender differences in asthma diagnosis in children; girls are less likely to be diagnosed with asthma than are boys, despite having similar symptoms. In a national study in the United Kingdom [27], the ISAAC protocol was used to measure wheezing and asthma diagnosis in a representative sample of 12- to 14-year-olds. Wheeze in the past 12 months was reported by 33.3% of respondents, and was more common in older children and in girls (odds ratio, 1.14; 95% CI, 1.08–1.20). Asthma diagnosis was reported by 20.9% of children but was less common in girls.

In a school study in Denmark, girls also were more likely to have undiagnosed asthma [28]. In this study of 495 children, 292 were selected at random and 203 were selected based on family history of asthma. Evaluation included peak flow, spirometry, methacholine challenge, and exercise testing. Subjects who had no asthma diagnosis but who had asthma symptoms and at least one positive test were considered to be undiagnosed asthmatics. Among those who had diagnosed asthma, 33% were girls, compared with 69% among those who were undiagnosed. Other factors that were associated independently with the underdiagnosis of asthma were low physical activity and high body mass index (BMI).

Overdiagnosis of asthma

Despite the National Asthma Education and Prevention Program [29] recommendations for assessment of lung function using peak flow or spirometry, in clinical practice asthma often is diagnosed based solely on respiratory symptoms. This may lead to overdiagnosis of asthma because respiratory symptoms in the adult population may be related to chronic obstructive pulmonary disease or other respiratory conditions.

In the United States, Macy and colleagues [30] used the Kaiser Permanente database in San Diego County, California to identify adult asthmatics. All members (18–64 years; mean age, 51 years) who had a hospital, emergency department, or outpatient visit for asthma or two or more dispensed prescriptions of asthma medication during 2001 were included ($n = 12,315$). Of these, 7460 were considered to be low risk; 400 low-risk patients were selected randomly for diagnostic evaluation. Asthma could be confirmed in only 62.2% (51/82) of the subjects who completed the clinical and pulmonary function evaluation.

Similar evidence of overdiagnosis was reported from Halifax, Nova Scotia, Canada [31]. Among 90 adults who were diagnosed as having asthma by a physician, 41% had no evidence of reversible airflow obstruction, and had negative methacholine challenge tests. Only 52.2% of subjects reported having undergone any pulmonary function testing previously. Among subjects in whom asthma was not confirmed, 62% were taking asthma medications.

Among 206 patients (mean age, 36 years) who were diagnosed with asthma and referred to the Asthma Center at Toronto Hospital [32], 129 (62.6%) did not have airway responsiveness on methacholine challenge tests. Of the patients who did not have airway responsiveness, 62% were receiving medication and had a

Box 2. Summary: asthma diagnosis

There is evidence that asthma is under- and overdiagnosed in a variety of countries and settings.
There is a suggestion that systematic bias in reporting may occur differentially by ethnicity and socioeconomic status.
A lack of diagnostic validity may influence survey prevalence data.

mean duration of medication use of 2 years. After specialist evaluation, 98 of 206 patients (47.6%) had confirmed asthma. This study was not population-based, and referral to the Asthma Center may overrepresent patients who have atypical presentations or treatment failures as compared to the general population of asthmatics.

In Goteborg, Sweden, two population-based primary care practices were studied; all adult patients who had an asthma consultation were eligible for an extensive asthma evaluation [33]. Of 123 eligible adults, 86 attended and 57 (66%) had an asthma diagnosis confirmed. Failure to confirm the diagnosis of asthma was more common in women (36%) than in men (29%) and in patients who were older than 50 years (47%).

In summary, no study has examined the validity of asthma diagnoses in pregnant women specifically. Nonetheless, evidence from adults, in general, and women of childbearing age, in particular, suggests that under- and overreporting is a probable occurrence. Moreover, some systematic bias is likely with respect to ethnicity and socioeconomic status. Much more research is required to investigate the validity of asthma diagnoses, in general, and in pregnant women, in particular (Box 2).

Symptoms and medication use

If asthma diagnoses have uncertain validity, is it possible to study asthma symptoms and asthma medication use, and what is the relationship between diagnosis, symptoms, and medication? Epidemiologic data on asthmatic pregnant women is sparse; many studies provide information only on the diagnosis of asthma, rather than on the frequency of symptoms and medication use related to asthma. In this section, we describe data from the women who had physician-diagnosed asthma from our cohort study that examined the effect of asthma and medication use on pregnancy outcomes. Although the population is limited to the northeastern United States, and may not be generalizable to other pregnant asthmatic women, it provides some of the most comprehensive and detailed information on symptom frequency, medication use, and emergency care among asthmatic women in pregnancy.

Symptoms and medication use in the year before pregnancy

Asthma symptoms (wheeze, chest tightness, shortness of breath, or persistent cough) are common in women who have physician-diagnosed asthma, before and during pregnancy. Of 941 women studied, nearly 80% had at least one asthma symptom—approximately two thirds had wheeze, shortness of breath, or chest tightness, and nearly half had persistent cough—during the year before pregnancy (Table 6). White, African American, and Hispanic women had similar frequencies of asthma symptoms, whereas women who were Asian or other race had lower frequencies of all asthma symptoms. Younger, less educated women were less likely to have asthma symptoms in the year before pregnancy, whereas

Table 6
Distribution of asthma symptoms in the year before pregnancy by selected population characteristics among women with self-reported history of physician-diagnosed asthma

Population characteristic	N ^a	Percent with wheeze	Percent with shortness of breath	Percent with chest tightness	Percent with persistent cough
Total population	941	67.3	69.7	62.2	46.5
Race					
White	560	69.3 ^b	72.7 ^b	64.1	45.0 ^c
African American	95	71.6 ^b	74.5 ^b	62.1	55.8 ^c
Hispanic	234	63.7 ^b	63.8 ^b	60.9	48.7 ^c
Asian/Other	46	52.2 ^b	52.2 ^b	46.8	34.8 ^c
Age (y)					
< 20	156	57.7 ^b	61.3 ^b	54.1 ^b	42.6
20 – <25	165	64.8 ^b	66.9 ^b	59.8 ^b	48.2
25 – <30	238	73.5 ^b	73.3 ^b	66.8 ^b	52.3
30 – <35	239	70.7 ^b	76.8 ^b	67.6 ^b	44.4
≥ 35	138	64.5 ^b	54.0 ^b	57.3 ^b	41.7
Education					
<High school	199	59.8 ^b	63.6	54.8	47.0 ^b
High school graduate	189	69.3 ^b	71.3	66.1	51.6 ^b
Some college	223	72.2 ^b	74.7	63.7	52.5 ^b
College graduate	167	72.5 ^b	69.1	65.9	39.3 ^b
>College graduate	158	62.7 ^b	69.7	61.9	38.8 ^b
BMI					
Underweight	103	62.1 ^b	68.9	65.0	47.6 ^b
Normal	457	64.8 ^b	67.8	59.5	39.9 ^b
Overweight	132	68.2 ^b	71.2	62.9	47.3 ^b
Obese	240	74.6 ^b	73.5	66.7	58.2 ^b
Smoked in year before pregnancy					
No	678	65.3 ^b	68.4	60.5 ^c	43.4 ^b
Yes	257	72.4 ^b	72.9	66.7 ^c	54.3 ^b
Pets kept in home					
No	428	63.8 ^b	65.4 ^b	58.3 ^b	45.9
Yes	508	70.3 ^b	73.3 ^b	65.6 ^b	47.0

^a Totals may differ due to missing values.
^b $\chi^2 P < .05$.
^c $.05 \leq P < .10$.

those who smoked or kept pets in the home were more likely to have asthma symptoms in the year before pregnancy. Increasing BMI was associated with increasing frequency of wheeze and persistent cough.

Consistent with the episodic and variable nature of asthma, the number of months during which a woman had symptoms in the past year ranged from 0 to 12 (Table 7). Most women (69%) had symptoms for less than 6 months during the year, whereas 24% were symptomatic for 10 or more months. In contrast, a smaller proportion of women (26%) took controller medications in the year before pregnancy, and only 13% took them for 10 or more months.

Table 7

Distribution of asthma symptoms and controller medication use in year before pregnancy among women with self-reported history of physician-diagnosed asthma

	N	%
Wheeze		
None	306	32.7
1–3 mo	255	27.2
4–6 mo	161	17.2
7–9 mo	57	6.1
10 or more mo	158	16.9
Shortness of breath		
None	281	30.3
1–3 mo	268	28.9
4–6 mo	164	17.7
7–9 mo	52	5.6
10 or more mo	163	17.6
Chest tightness		
None	352	37.7
1–3 mo	267	28.6
4–6 mo	146	15.6
7–9 mo	45	4.8
10 or more mo	124	13.3
Persistent cough		
None	501	53.6
1–3 mo	219	23.4
4–6 mo	98	10.5
7–9 mo	28	3.0
10 or more mo	89	9.5
Any asthma symptom (wheeze or chest tightness or persistent cough)		
None	197	21.0
1–3 mo	266	28.4
4–6 mo	184	19.6
7–9 mo	69	7.4
10 or more mo	221	23.6
Controller medication use		
None	694	73.8
1–3 mo	87	9.2
4–6 mo	22	2.3
7–9 mo	19	2.0
10 or more mo	119	12.6

Frequency of symptoms was related to controller medication use in the year before pregnancy; those who had more symptoms were more likely to use controller medications (inhaled steroids, leukotriene inhibitors, cromones, theophylline, long-acting β_2 agonists, or systemic steroids). Most women in each symptom frequency group, however, including those who had symptoms for at least 10 months in the year, did not take controller medications. Only 22% of women with 1 to 3 months of asthma symptoms, 31% with 4 to 6 months of asthma symptoms, 52% with 7 to 9 months of asthma symptoms, and 42% with 10 or more months of asthma symptoms in the year before pregnancy reported using any controller medication in that year.

Table 8
Average Global Initiative for Asthma treatment step in year before pregnancy by selected study population characteristics among women with self-reported history of physician-diagnosed asthma

Population characteristic	Total		Average GINA treatment step in year before pregnancy (%)				
	N ^a	%	0	1	2	3	4
Total	941	100.0	38.7	42.2	12.7	4.1	2.3
Race							
White	561	59.8	35.6 ^b	40 ^b	16.2 ^b	5.2 ^b	3.0 ^b
African American	96	10.2	40.6 ^b	43.8 ^b	11.5 ^b	1.0 ^b	3.1 ^b
Hispanic	235	25.0	42.1 ^b	48.1 ^b	6.4 ^b	2.6 ^b	0.8 ^b
Asian/other	47	5.0	55.2 ^b	36.2 ^b	4.3 ^b	4.3 ^b	0.0 ^b
Age							
<20	158	16.8	44.9 ^b	50.7 ^b	3.8 ^b	0.6 ^b	0.0 ^b
20–<25	166	17.7	42.2 ^b	44.6 ^b	10.8 ^b	1.2 ^b	1.2 ^b
25–<30	238	25.3	36.6 ^b	39.5 ^b	14.7 ^b	4.2 ^b	5.0 ^b
30–<35	239	25.4	31.8 ^b	43.6 ^b	14.6 ^b	7.5 ^b	2.5 ^b
>35	139	14.8	43.9 ^b	31.6 ^b	17.3 ^b	5.8 ^b	1.4 ^b
Education							
<High school	201	21.4	43.3 ^b	47.7 ^b	6.5 ^b	1.5 ^b	1.0 ^b
High school graduate	190	20.2	42.1 ^b	42.1 ^b	11.6 ^b	2.6 ^b	1.6 ^b
Some college	223	23.7	39.0 ^b	41.7 ^b	13.9 ^b	3.6 ^b	1.8 ^b
College graduate	168	17.9	33.3 ^b	44.0 ^b	13.1 ^b	6.6 ^b	3.0 ^b
>College graduate	158	16.8	34.2 ^b	33.5 ^b	19.6 ^b	7.6 ^b	5.1 ^b
BMI							
Underweight	103	11.0	41.7	40.8	10.7	3.9	2.9
Normal	459	49.1	39.9	41.8	11.1	4.4	2.8
Overweight	132	14.1	43.9	40.9	11.4	3.0	0.8
Obese	242	25.8	32.6	44.2	16.5	4.6	2.1
Smoked in year before pregnancy							
No	680	72.4	37.6	42.3	12.9	4.4	2.8
Yes	259	27.6	42.0	41.7	12.0	3.1	1.2
Pets kept in home							
No	430	45.7	40.5	42.2	11.9	3.5	1.9
Yes	510	54.3	37.4	42.0	13.3	4.5	2.8

^a Totals may differ due to missing values.
^b χ^2 $P < .05$.

Most women in this population were not taking medications routinely to control their asthma, and this was especially true for young, Hispanic, and less educated women (Table 8). Only 19% of the study population had an average Global Initiative for Asthma (GINA) treatment step of 2 or higher in the year before pregnancy, a level that would indicate consistent, regular use of controller medications. Nearly one quarter of white women, compared with 16% of African American and 10% of Hispanic women, had an average treatment step of 2 or higher. Similarly, a much larger proportion of women aged 25 and older, and those who were well educated, used controller medications regularly during the year before pregnancy.

Symptoms and medication use during pregnancy

Symptoms were equally common during pregnancy as before pregnancy in this group of asthmatic women. Only 12% had no symptoms during pregnancy, and 46% had an average GINA symptom step of 1, compared with 16% who had symptoms almost daily across pregnancy (GINA symptom step of 3 or 4; Table 9). Again, a much larger proportion (41%) of women did not take asthma medications, especially controller medications, during pregnancy. Only 17% of women had an average treatment step of 2 or higher (regular use of controller medications) in pregnancy.

White and African American women were more likely to have moderate-severe persistent asthma, on average, in pregnancy than were Hispanic or Asian/other women (Table 10). A smaller percentage of younger women had moderate-severe persistent asthma than did those who were 25 to 35 years old. Women who smoked in pregnancy and those who kept pets in their homes were more likely to have a higher average symptom step.

Table 9

Average and maximum Global Initiative for Asthma symptom and treatment steps across pregnancy among women with self-reported history of physician-diagnosed asthma

	Average across pregnancy		Maximum across pregnancy	
	N	%	N	%
GINA symptom step				
Step 0 – no symptoms	105	12.0	105	12.0
Step 1	403	46.3	114	13.1
Step 2	227	26.0	257	29.5
Step 3	104	11.9	152	17.4
Step 4	33	3.8	244	28.0
GINA treatment step				
Step 0 – no medications	356	40.8	356	40.8
Step 1	372	42.6	303	34.8
Step 2	106	12.2	133	15.2
Step 3	28	3.2	59	6.8
Step 4	10	1.2	21	2.4

Table 10
Global Initiative for Asthma symptom and treatment steps averaged across pregnancy among women with self-reported history of physician-diagnosed asthma (n = 941) in the Asthma in Pregnancy Study, 1996–2001

Population characteristic	GINA symptom step (%)					GINA treatment step (%)				
	0	1	2	3	4	0	1	2	3	4
Total population	12.1	46.2	26.1	11.8	3.8	40.8	42.7	12.2	3.1	1.2
Race										
White	10.2 ^a	45.3 ^a	25.7 ^a	14.2 ^a	4.6 ^a	39.4	41.1	14.0	3.8	1.7
African American	13.0 ^a	45.7 ^a	22.8 ^a	12.0 ^a	6.5 ^a	41.3	45.6	9.8	2.2	1.1
Hispanic	14.6 ^a	47.9 ^a	29.1 ^a	7.5 ^a	0.9 ^a	41.3	47.4	9.9	1.4	0.0
Asian/other	20.4 ^a	50.1 ^a	20.4 ^a	6.8 ^a	2.3 ^a	54.5 ^a	34.1	6.8	4.6	0.0
Age										
<20	14.4 ^a	55.5 ^a	22.6 ^a	4.8 ^a	2.7 ^a	41.2 ^a	50.6 ^a	7.5 ^a	0.7 ^a	0.0 ^a
20 to <25	12.3 ^a	41 ^a	31.8 ^a	11.0 ^a	3.9 ^a	42.9 ^a	45.5 ^a	11.0 ^a	0.0 ^a	0.6 ^a
25 to <30	11.6 ^a	44.4 ^a	27.6 ^a	12.0 ^a	4.4 ^a	42.2 ^a	38.7 ^a	13.3 ^a	4.9 ^a	0.9 ^a
30 to <35	11.2 ^a	45.5 ^a	22.8 ^a	18.3 ^a	2.2 ^a	37.5 ^a	42.4 ^a	13.4 ^a	5.4 ^a	1.3 ^a
≥35	11.5 ^a	46.7 ^a	26.2 ^a	9.0 ^a	6.6 ^a	41.0 ^a	38.5 ^a	13.9 ^a	3.3 ^a	3.3 ^a
Education										
<High school	12.5 ^b	50.5 ^b	28.3 ^b	4.9 ^b	3.8 ^b	40.2 ^a	46.2 ^a	12.0 ^a	1.6 ^a	0.0 ^a
High school graduate	11.8 ^b	45 ^b	27.5 ^b	12.9 ^b	2.8 ^b	43.4 ^a	40.4 ^a	14.0 ^a	1.1 ^a	1.1 ^a
Some college	13.5 ^b	37.9 ^b	26.0 ^b	16.8 ^b	5.8 ^b	42.8 ^a	44.3 ^a	8.6 ^a	3.8 ^a	0.5 ^a
College graduate	13.5 ^b	48.0 ^b	23.1 ^b	12.2 ^b	3.2 ^b	35.9 ^a	47.7 ^a	10.3 ^a	3.8 ^a	2.3 ^a
>College graduate	8.3 ^b	52.4 ^b	24.1 ^b	12.4 ^b	2.8 ^b	40.7 ^a	33.8 ^a	17.2 ^a	6.2 ^a	2.1 ^a
BMI										
Underweight	15.6	42.7	27.1	10.4	5.2	52.1 ^a	30.2 ^a	12.5 ^a	3.1 ^a	2.1 ^a
Normal	12.6	50.5	23.6	11.0	2.3	42.2 ^a	44.2 ^a	8.7 ^a	4.2 ^a	0.7 ^a
Overweight	11.5	45.9	29.5	9.8	3.3	35.2 ^a	45.1 ^a	16.4 ^a	2.5 ^a	0.8 ^a
Obese	9.0	41.0	27.9	15.8	6.3	36.0 ^a	44.2 ^a	16.2 ^a	1.8 ^a	1.8 ^a
First trimester smoking										
No	12.4 ^a	48.3 ^a	25.2 ^a	11.1 ^a	3.0 ^a	40.1	43.6	11.2	3.6	1.5
Yes	10.9 ^a	38.9 ^a	28.5 ^a	15.0 ^a	6.7 ^a	44.0	38.9	15.0	2.1	0.0
Third trimester smoking										
No	12.0 ^b	48.2 ^b	25.3 ^b	11.7 ^b	2.8 ^b	40.3	42.9	11.8	3.7	1.3
Yes	10.8 ^b	37.9 ^b	29.7 ^b	13.5 ^b	8.1 ^b	47.3	40.5	10.8	1.4	0.0
Pets kept in home										
No	14.1 ^a	48.9 ^a	24.6 ^a	8.9 ^a	3.5 ^a	42.4	44.5	10.2	2.2	0.7
Yes	10.3 ^a	44.0 ^a	27.1 ^a	14.5 ^a	4.1 ^a	39.5	41.2	13.7	4.1	1.5

^a $\chi^2 P < .05$.
^b $.05 \leq P < .10$.

Younger women were less likely to take controller medications regularly than were older women, and well-educated women were more likely to take them (see Table 10). Women with normal BMI were less likely to take controller medications regularly in pregnancy than were overweight or obese women. Unlike in the year before pregnancy, race was not associated with average treatment step during pregnancy.

Although women who had more frequent symptoms in the year before pregnancy were more likely to have a higher average symptom step in pregnancy, approximately 75% of women who had no symptoms in the year before preg-

Table 11

Average Global Initiative for Asthma symptom and treatment steps across pregnancy by number months of asthma symptoms^a in year before pregnancy among women with self-reported history of physician-diagnosed asthma

	Number of months of asthma symptoms in year before pregnancy				
	None	1–3 mo	4–6 mo	7–9 mo	10+ mo
	(n = 186)	(n = 247)	(n = 167)	(n = 64)	(n = 204)
	%	%	%	%	%
Average GINA symptom step across pregnancy					
No symptoms	25.8	15.4	6.6	1.6	2.9
Step 1	54.3	55.4	50.3	45.3	24.5
Step 2	14.5	22.3	30.5	28.1	36.8
Step 3	5.4	6.1	11.4	17.2	24.0
Step 4	0.0	0.8	1.2	7.8	11.8
Average GINA treatment step across pregnancy					
No medication use	71.5	46.5	32.9	15.6	20.6
Step 1	25.3	46.2	50.3	54.7	43.6
Step 2	2.7	4.9	13.2	20.3	26.5
Step 3	0.0	2.0	3.6	7.8	5.9
Step 4	0.5	0.4	0.0	1.6	3.4

^a Asthma symptoms include: wheeze, shortness of breath, chest tightness, or persistent cough in year before pregnancy (shortness of breath was not included in GINA categorization during pregnancy because many pregnant women experience shortness of breath unrelated to respiratory function).

nancy had symptoms during pregnancy (Table 11). In contrast, nearly all women who had symptoms for at least 4 months in the year before pregnancy had symptoms during pregnancy; 35.8% of those who had symptoms for at least 10 months in the year before pregnancy had an average symptom step of 3 or 4 (daily symptoms) during pregnancy.

Few women who were asymptomatic during the year before pregnancy took controller medications in pregnancy (see Table 11). Asthma treatment during pregnancy was associated positively with months of symptoms during the year before pregnancy. From 7.3% of women who had symptoms for 1 to 3 months in the year before pregnancy to 35.8% of those who had symptoms for at least 10 months in the year before pregnancy had an average GINA treatment step of 2

Table 12

Use of asthma medications in pregnancy by average Global Initiative for Asthma symptom step across pregnancy among women with self-reported history of physician-diagnosed asthma

Average GINA symptom step across pregnancy	Asthma medication use in pregnancy					
	No medication		Rescue medication only		1+ controller medication	
	N	%	N	%	N	%
No symptoms	94	89.5	4	3.8	7	6.7
Intermittent	175	43.5	169	41.9	59	14.6
Mild persistent	66	29.1	81	35.7	80	35.2
Moderate persistent	19	18.3	36	34.6	49	47.1
Severe persistent	2	6.1	13	39.4	18	54.5

Box 3. Summary: asthma symptoms and medication use

- Symptoms (wheeze, chest tightness, persistent cough) are common before and during pregnancy among women who have a diagnosis of asthma
 - 80% had one or more symptoms in the year before pregnancy
 - 88% had one or more symptoms during pregnancy; 16% had symptoms almost daily
- Symptoms tended to be episodic before and during pregnancy
 - 69% had symptoms for less than 6 months in the past year; 24% were symptomatic for at least 10 months
 - 46% of women had an average GINA symptom step of 1 (intermittent) across pregnancy; 16% had symptoms almost daily (average GINA symptom step of 3 or 4)
- Asthma medication use before and during pregnancy was much less common than were symptoms in these asthmatic women
 - Only 26% took any asthma controller medication (inhaled steroids, leukotriene inhibitors, cromones, theophylline, long-acting β_2 agonists, or systemic steroids) in the year before pregnancy; 13% took controller medications for at least 10 months in that year.
 - Even among women with 10 or more months of symptoms in the year before pregnancy, only 42% reported using any controller medication in that year.
 - Only 17% of the women took any controller medication (average GINA treatment step of 2 or higher) regularly in pregnancy.
- Many asthmatic women who did not have symptoms in the year before pregnancy had symptoms during pregnancy
- 75% of women who had no reported symptoms in the year before pregnancy had symptoms during pregnancy
- Nearly all women who had symptoms for at least 4 months in the year before pregnancy had symptoms during pregnancy
- Few women who were asymptomatic in the year before pregnancy took controller medications in pregnancy
- About half of women who took controller medications before pregnancy took them during pregnancy
- Only about half of women who had daily symptoms during pregnancy took any controller medications in pregnancy

Table 13

Emergency room visits and hospitalizations in the year before and during pregnancy among women with self-reported history of physician-diagnosed asthma

	n	%
Year before pregnancy		
No ER visits or hospitalizations	658	88.9
ER visits, but no hospitalizations	65	8.8
Hospitalizations ($\pm$ ER visits)	17	2.3
During pregnancy		
No ER visits or hospitalizations	690	92.3
ER visits, but no hospitalizations	38	5.1
Hospitalizations ($\pm$ ER visits)	12	1.6

Abbreviation: ER, emergency room.

or higher (controller medication use) during pregnancy. Only 3.5% of women who did not take controller medications in the year before pregnancy took them during pregnancy, compared with 58% of women who took controller medication in the year before pregnancy.

Table 12 shows the association between asthma medication use during pregnancy and the frequency of symptoms during pregnancy. Women who had a higher average symptom step during pregnancy were more likely to take one or more controller medications during pregnancy; however, only approximately half of the 137 women who had almost daily symptoms during pregnancy took any controller medications in pregnancy (Box 3).

Emergent care for asthma

Approximately 11% of women had an emergency visit or hospitalization for asthma in the year before pregnancy; 2% were hospitalizations (Table 13). During pregnancy, 6.7% had emergent care for asthma, of which 1.6% were hospitalizations.

Women who had asthma-related emergency care in the year before pregnancy also were more likely to have emergency care during pregnancy (Table 14). Only

Table 14

Emergency room visits and hospitalizations during pregnancy by visits in the year before pregnancy among women with self-reported history of physician-diagnosed asthma

	N	During pregnancy		
		No ER visits or hospitalizations (%)	ER visits, but no hospitalizations (%)	Hospitalizations ($\pm$ ER visits) (%)
No ER visits or hospitalizations	658	95.2	4.0	0.8
ER visits, but no hospitalizations	65	81.6	13.8	4.6
Hospitalizations ($\pm$ ER visits)	17	58.8	17.7	23.5

Abbreviation: ER, emergency room.

Table 15
Global Initiative for Asthma treatment step in year before and during pregnancy by emergency room visits and hospitalizations in the year before pregnancy among women with self-reported history of physician-diagnosed asthma

GINA treatment step	Year before pregnancy		
	No ER visits or hospitalizations (%)	ER visits, but no hospitalizations (%)	Hospitalizations (± ER visits) (%)
Year before pregnancy			
Step 0: No asthma medications	42.5	6.6	13.6
Step 1: Rescue medications only	41.7	46.1	45.4
Step 2: One controller medications	11.2	30.3	13.6
Step 3: Two controllers medications	3.3	10.5	9.1
Step 4: Three+ controller medications	1.4	6.6	18.2
During pregnancy			
Step 0: No asthma medications	43.2	17.8	25.0
Step 1: Rescue medications only	43.2	42.5	30.0
Step 2: One controller medications	9.9	27.4	40.0
Step 3: Two controller medications	2.6	9.6	5.0
Step 4: Three+ controller medications	0.9	2.7	0.0

Abbreviation: ER, emergency room.

4.8% of women with no emergency department visits or hospitalization in the year before pregnancy had an emergency department visit or hospitalization during pregnancy, compared with 18.5% of those who had a previous emergency department visit, and 41.2% of those who were hospitalized in the previous year.

Women who had earlier emergency room visits or hospitalizations were more likely to have taken controller medications in the year before pregnancy (46%) and during pregnancy (41%) than were women who had no emergent care (~16%; Table 15). Nevertheless, 45% of these women took no controller medications at all in pregnancy, and more than half did not take them on a regular basis (average treatment step of 2 or higher) before or during pregnancy.

Summary

We demonstrated that asthma remains a common condition among pregnant women and that the prevalence of self-reported asthma in the United States is between 8.4% and 8.8%. In addition, approximately 4.1% of all pregnant women

experienced an asthma attack in the previous year. Prevalence rates in other countries seem to be higher or substantially lower; however, further characterization of international trends using nationally representative data is needed. Data from a large prospective cohort study in the northeastern United States and national data demonstrate continued opportunities for population-level improvement in well-managed asthma during pregnancy. Finally, asthma diagnosis and asthma control seem to differ by population characteristics (eg, age, race/ethnicity, socioeconomic status), and further research and clinical involvement are needed to address potentially systematic variation in reporting and management of the disease.

Appendix 1. The Yale Asthma in Pregnancy Study: methods

We conducted a large, prospective cohort study of pregnant asthmatic and nonasthmatic women to assess the association between asthma/asthma therapy on birth outcomes. The study has been described in detail in previous publications [34,35]. Pregnant women were recruited from 56 obstetric practices and 15 clinics associated with six participating hospitals in Connecticut and Massachusetts. More than 11,400 women were screened for eligibility between April 1997 and June 2000. Exclusion criteria included having insulin-dependent diabetes mellitus, intending to terminate the pregnancy, not speaking English or Spanish, or being more than 24 weeks' gestation at enrollment. All women who had a self-reported history of physician-diagnosed asthma ($n=1343$) and a simple random sample of 1.5 to 1 nonasthmatics ($n=2070$) were invited to participate; a total of 2379 enrolled, of whom 941 had asthma. These 941 asthmatics provide information on the characteristics of asthmatic women in pregnancy.

Detailed information on asthma symptoms and medication use in the year before pregnancy and during pregnancy was collected using structured in-person interviews at enrollment and post partum, and telephone interviews at 20, 28, and 36 weeks' gestation. This information was used to classify the severity of women's asthma during pregnancy according to a modification of the 2002 GINA guidelines [36]. GINA symptom and treatment steps were calculated for each month of pregnancy, and were used to derive an average and maximum symptom and treatment step across pregnancy. For the average GINA symptom and treatment steps, monthly steps were averaged over the number of months of pregnancy and rounded up to the next highest integer. Maximum symptom and treatment steps were the highest step recorded during the pregnancy. Only women who had singleton live births were classified according to these criteria.

Symptom steps were defined as follows:

Step 0: No symptoms during pregnancy

Step 1: Intermittent asthma: symptoms 1 to 7 days per month on average, or nocturnal symptoms less than 2 nights per month

Step 2: Mild persistent asthma: symptoms more than 7 days but not every day per month, or nocturnal symptoms 2 to 7 nights per month

Step 3: Moderate persistent asthma: symptoms daily, and nocturnal symptoms less than 14 nights per month

Step 4: Severe persistent asthma: symptoms daily, and nocturnal symptoms at least 14 nights per month

Asthma symptoms included self-reported wheeze, chest tightness or persistent cough.

Treatment steps were defined as:

Step 0: No asthma medication use during pregnancy

Step 1: Intermittent. No daily controller medications; rescue medications used as needed.

Step 2: Mild persistent. One controller medication (usually inhaled steroid).

Step 3: Moderate persistent. Two controller medications.

Step 4: Severe persistent. Three or more controller medications.

Asthma controller medications included systemic steroids, inhaled steroids, long-acting β_2 -agonists, leukotriene inhibitors, cromones, and xanthine derivatives (eg, theophylline).

Information on emergency visits and hospitalizations was obtained from women at home interview and postpartum interview. Information on emergency visits and hospitalizations during the year before pregnancy was obtained at the initial home interview. In addition, a total of 740 of the 941 asthmatic women with a singleton live birth completed a postpartum interview shortly after the baby was born. At this interview, information on all emergency room visits and hospitalizations during pregnancy was ascertained.

References

- [1] National Asthma Education and Prevention Program Asthma and Pregnancy Working Group, National Heart, Lung, and Blood Institute. NAEPP expert panel report. Managing asthma during pregnancy: recommendations for pharmacologic treatment—2004 update. *J Allergy Clin Immunol* 2005;115:34–46.
- [2] Namazy JA, Schatz M. Pregnancy and asthma: recent developments. *Curr Opin Pulm Med* 2005; 11(1):56–60.
- [3] Weiss KB, Gergen PJ, Wagener DK. Breathing better or worse? The changing epidemiology of asthma morbidity and mortality. *Ann Rev Pub Health* 1993;14:491–513.
- [4] Mannino DM, Homa DM, Pertowski CA, et al. Surveillance of asthma—United States, 1960–1995. *MMWR CDC Surveill Summ* 1998;47(1):1–27.
- [5] Kwon HL, Belanger K, Bracken MB. Asthma prevalence among pregnant and childbearing-aged women in the United States: estimates from national health surveys. *Ann Epidemiol* 2003; 13(5):317–24.
- [6] National Center for Health Statistics. Design and estimation for the National Health Interview Survey, 1995–2004. Vital and Health Statistics. Hyattsville, MD: National Center for Health Statistics; 2000 [Series 2, No. 130].
- [7] National Center for Health Statistics. Plan and operation of the Third National Health and

- Nutrition Examination Survey, 1988–1994. Vital Health Statistics. Hyattsville, MD: National Center for Health Statistics; 1994 [Series 1, No. 32].
- [8] McDowell A, Engel A, Massey JT, et al. Plan and operation of the Second National Health and Nutrition Examination Survey, 1976–1980. Vital Health Statistics. Hyattsville, MD: National Center for Health Statistics; 1981 [Series 1, No. 15].
- [9] Centers for Disease Control and Prevention. Behavioral Risk Factor Surveillance System user's guide. Atlanta (GA): Centers for Disease Control and Prevention; 1998.
- [10] Centers for Disease Control and Prevention. Self-reported asthma prevalence among adults—United States, 2000. *MMWR Morb Mortal Wkly Rep* 2001;50(32):682–6.
- [11] Behavioral Risk Factor Surveillance System Branch, Office of Surveillance and Analysis. 2003 Behavioral risk factor surveillance summary data quality report. Atlanta (GA): Centers for Disease Control and Prevention; 2004.
- [12] Alexander S, Dodds L, Armson BA. Perinatal outcomes in women with asthma during pregnancy. *Obstet Gynecol* 1998;92(3):435–40.
- [13] Kurinczuk JJ, Parsons DE, Dawes V, et al. The relationship between asthma and smoking during pregnancy. *Women Health* 1999;29(3):31–47.
- [14] Ellegård E, Hellgren M, Torén K, et al. The incidence of pregnancy rhinitis. *Gynecol Obstet Invest* 2000;49(2):98–101.
- [15] Källén B, Rydhstroem H, Åberg A. Asthma during pregnancy—a population-based study. *Eur J Epidemiol* 2000;16:167–71.
- [16] Wen SW, Demissie KW, Liu S. Adverse outcomes in pregnancies of asthmatic women: results from a Canadian population. *Ann Epidemiol* 2001;11(1):7–12.
- [17] Pereira LS, Lira Plascencia J, Ahued Ahued R, et al. Maternal morbidity in adolescent pregnancy. *Ginecol Obstet Mex* 2002;70:270–4.
- [18] Bager P, Melbye M, Rostgaard K, et al. Mode of delivery and risk of allergic rhinitis and asthma. *J Allergy Clin Immunol* 2003;111(1):51–6.
- [19] Karmaus W, Eneli I. Maternal atopy and the number of offspring: is there an association? *Pediatr Allergy Immunol* 2003;14(6):470–4.
- [20] Frey U, Kuehni C, Roiha H, et al. Maternal atopic disease modifies effects of prenatal risk factors on exhaled nitric oxide in infants. *Am J Respir Crit Care Med* 2004;170(3):260–5.
- [21] Miyake Y, Miyamoto S, Ohya Y, et al. Osaka Maternal and Child Health Study Group. Association of active and passive smoking with allergic disorders in pregnant Japanese women: baseline data from the Osaka Maternal and Child Health Study. *Ann Allergy Asthma Immunol* 2005;94(6):644–51.
- [22] Westergaard T, Rostgaard K, Wohlfahrt J, et al. Sibship characteristics and risk of allergic rhinitis and asthma. *Am J Epidemiol* 2005;162(2):125–32.
- [23] The International Study of Asthma and Allergies in Childhood (ISAAC) Steering Committee. Worldwide variations in the prevalence of symptoms of atopic eczema in the International Study of Asthma and Allergies in Childhood. *J Allergy Clin Immunol* 1999;103(1 Pt 1):125–38.
- [24] European Community Respiratory Health Survey. Variations in the prevalence of respiratory symptoms, self-reported asthma attacks, and use of asthma medication in the European Community Respiratory Health Survey (ECRHS). *Eur Respir J* 1996;9(4):687–95.
- [25] Akinbami LJ, Rhodes JC, Lara M. Racial and ethnic differences in asthma diagnosis among children who wheeze. *Pediatrics* 2005;115(5):1254–60.
- [26] Ng Man Kwong G, Das C, Proctor AR, et al. Diagnostic and treatment behaviour in children with chronic respiratory symptoms: relationship with socioeconomic factors. *Thorax* 2002;57(8):701–4.
- [27] Kaur B, Anderson HR, Austin J, et al. Prevalence of asthma symptoms, diagnosis, and treatment in 12–14-year-old children across Great Britain (international study of asthma and allergies in childhood, ISAAC UK). *BMJ* 1998;316(7125):118–24.
- [28] Siersted HC, Boldsen J, Hansen HS, et al. Population-based study of risk factors for under-diagnosis of asthma in adolescence: Odense schoolchild study. *BMJ* 1998;316(7132):651–5.
- [29] NAEPP Expert Panel Report. Guidelines for the Diagnosis and Management of Asthma—Update on Selected Topics 2002. Bethesda (MD): National Institutes of Health: National Heart, Lung, and Blood Institute; 2003, Publication #NIH 02–5074.

- [30] Macy E, Schatz M, Gibbons C, et al. The prevalence of reversible airflow obstruction and/or methacholine hyperreactivity in random adult asthma patients identified by administrative data. *J Asthma* 2005;42(3):213–20.
- [31] LindenSmith J, Morrison D, Deveau C, et al. Overdiagnosis of asthma in the community. *Can Respir J* 2004;11(2):111–6.
- [32] Joyce DP, Chapman KR, Kesten S. Prior diagnosis and treatment of patients with normal results of methacholine challenge and unexplained respiratory symptoms. *Chest* 1996;109(3):697–701.
- [33] Marklund B, Tunsater A, Bengtsson C. How often is the diagnosis bronchial asthma correct? *Fam Pract* 1999;16(2):112–6.
- [34] Triche EW, Saftlas AF, Belanger K, et al. Association of asthma diagnosis, severity, symptoms and treatment with preeclampsia. *Obstet Gynecol* 2004;104(3):585–93.
- [35] Bracken MB, Triche EW, Belanger K, et al. Asthma symptoms, severity and drug therapy: a prospective study of effects on 2205 pregnancies. *Obstet Gynecol* 2003;102(4):739–52.
- [36] Global Initiative for Asthma. NHLBI/WHO Workshop Report: Global Strategy for Asthma Management and Prevention. National Institutes of Health, National Heart, Lung, and Blood Institute; 2002 [Publication #NIH 02–3659].