
Asthma in pregnancy and its pharmacologic treatment

Carol Louik, ScD*; Michael Schatz, MD, MS†; Sonia Hernández-Díaz, MD, ScD*‡; Martha M. Werler, ScD*; and Allen A. Mitchell, MD*

Background: Asthma is among the most common serious medical problems in pregnancy, and its prevalence may be increasing. Management is problematic because asthma may harm the fetus, yet little is known about fetal risks of asthma medications.

Objective: To examine the prevalence, symptom control, and pharmacologic treatment of asthma in pregnancy.

Methods: Study participants were a random sample of 3,609 mothers of nonmalformed infants born in Massachusetts between 1998 and 2006. Interviewed within 6 months of delivery, participants were asked specific asthma-related questions and classified as having physician-diagnosed, possible, past, or no asthma; those with physician-diagnosed asthma were classified as having well-controlled, not well-controlled, or poorly controlled asthma. Drug treatments were grouped into corticosteroids, β_2 -agonists, leukotriene modifiers, combination products, and others.

Results: Physician-diagnosed asthma was present in 502 women (13.9%) and possible asthma in an additional 578 (16.0%). Higher rates of asthma were observed among women who were younger, white, obese, and less well educated, had lower income, and smoked during pregnancy. Secular changes were unremarkable: leukotriene modifiers were used by only 3.4% of asthmatic women; inhaled steroid use increased only from 19.0% during 1997–1999 to 23.3% in 2003–2005, whereas use of inhaled β_2 -agonists exceeded 50% in both periods. Less than 40% of women with poorly controlled asthma symptoms reported use of a controller medication.

Conclusions: High rates of asthma and asthma symptoms, together with the low rates of use of controller medications, underscore the need to better understand the risks and safety of asthma medications during pregnancy.

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INTRODUCTION

Asthma is among the most common serious medical problems in pregnancy,¹ estimated to affect between 3.7% and 8.4% of pregnant women.² Furthermore, population data suggest that these rates may be increasing.^{3,4} Management of asthma in pregnancy poses a dilemma for both physicians and

their pregnant patients: asthma may itself present risks to the fetus, such as low birth weight and premature delivery,^{5,6} but the fetal risks of medications used to treat asthma are largely unknown. To improve management, the National Asthma Education and Prevention Program (NAEPP) has published recommendations for treatment of asthma in pregnancy, initially in 1993⁷ and most recently in January 2005,¹ which advise that inhaled steroids be used as first-line treatment for persistent asthma. However, the extent to which these guidelines are followed is unclear.

Using data on mothers of nonmalformed infants collected as part of an ongoing program of case-control surveillance of risk factors for birth defects, we examined the prevalence of asthma, levels of asthma control, the use of asthma medications among pregnant women, and the relationship between pregnancy and asthma symptoms. By examining trends in the use of specific asthma medications over time, we also evaluated the impact of changes in both asthma treatment guidelines and the introduction of new medications.

METHODS

The Slone Epidemiology Center at Boston University has been conducting case-control surveillance to identify risk factors for birth defects since 1976; the methods have been described previously.^{8,9} In 1998, we began including in our study population a random sample of Massachusetts births of nonmalformed infants. On a bimonthly basis, the Slone Ep-

Affiliations: * Slone Epidemiology Center at Boston University, Boston, Massachusetts; † Department of Allergy, Kaiser Permanente Medical Center, San Diego, California; ‡ Department of Epidemiology, Harvard School of Public Health, Boston, Massachusetts.

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idemiology Center receives a data file from the Massachusetts Department of Public Health containing all births reported in the previous 5 months, and from this file, a random sample of mothers of infants between 12 and 18 weeks of age are invited to participate in the study. Known neonatal deaths are excluded. The current report is based on this population-based sample of mothers of nonmalformed infants born in Massachusetts between 1998 and 2006.

Mothers of eligible study participants are interviewed within 6 months of the infant's birth by trained nurse interviewers using a standardized questionnaire. The interview elicits demographic information about the mother and father and detailed information regarding maternal illnesses and details of all medications used 2 months before the last menstrual period (LMP) through the end of pregnancy. This study has been approved by Boston University Medical Center's institutional review board and the institutional review boards of all participating institutions as appropriate, and verbal informed consent is obtained from all participants.

The interview included a series of questions related specifically to asthma diagnosis, symptoms, and management. The questions began by asking about the presence, in the past 5 years, of physician-diagnosed asthma, bronchitis, or reactive airway disease. Because 1 objective of these questions was to identify women who may have had undiagnosed asthma, women who responded no to these questions were asked whether, within the past 5 years, they had experienced episodes of coughing, wheezing, chest tightness, or shortness of breath. Women who responded affirmatively were asked about the timing of these symptoms: whether they occurred seasonally; at night; during or after colds; after exercise; after exposure to animals, cut grass, or dust; or only during pregnancy. They were also asked whether their symptoms changed during pregnancy and, if so, the date of the change. Next, a series of questions inquired about level of asthma control: whether asthma required unscheduled medical visits, prednisone or cortisone, hospitalization, or intubation. Finally, women were asked questions relating to the extent to which their symptoms interfered with activities or sleep.

The asthma-related questions were the basis for classifying the likelihood of asthma. *Physician-diagnosed asthma* was defined as health care professional–diagnosed asthma that was present within the past 5 years. *Possible asthma* was defined as either (1) bronchitis, wheezing, chest tightness, or persistent cough within the past 5 years or (2) shortness of breath in the past 5 years with at least 1 positive response (other than “only during pregnancy”) to the questions about timing of symptoms. *Past asthma* was defined as physician-diagnosed asthma that was not present within the past 5 years. Individuals not meeting these definitions were classified in the *no asthma* group.

We also created a scale reflecting the degree of symptom control for physician-diagnosed asthma. Asthma that required hospitalization or involved symptoms that were reported to interfere with activities or sleep “constantly” was considered to be *poorly controlled*. Asthma that required the use of

prednisone, caused 1 or more unscheduled medical visits, or involved symptoms that interfered with activities or sleep “often” was considered to be *not well controlled* (this is modeled after the Expert Panel Report 3¹⁰ definition, which could not be directly applied here because of the 9-month pregnancy timeframe vs the 12-month Expert Panel Report 3 risk domain timeframe). Remaining cases of physician-diagnosed asthma were classified as *well controlled*.

Because symptom frequency and pulmonary function were not captured, the NAEPP severity and control classification could not be used. However, symptoms interfering with sleep and activity are part of the impairment domain of asthma severity and control, and exacerbations requiring oral corticosteroids are part of the risk domains of asthma severity and control.¹⁰ Although this study predated the publication of validated asthma control questionnaires,^{11–13} questions regarding asthma symptoms interfering with sleep and activity are included in all of those tools.

Drug treatments were grouped into 5 major classes: corticosteroids, β_2 -agonists, leukotriene modifiers, combination products, and others (primarily mast cell stabilizers). Corticosteroids and β_2 -agonists were further subdivided according to route of administration. Exposure was considered separately for each of these classes and, where numbers were sufficient, for specific medications. We also classified asthma medications as either controller or reliever drugs: controllers included inhaled steroids, salmeterol, cromolyn, nedocromil, theophylline, leukotriene modifiers, and formoterol; relievers included all other asthma medications.

We examined rates of asthma among study women, identified factors associated with asthma presence and control, examined the timing and direction of changes in the control of symptoms during pregnancy, and determined rates of use of the various classes of medication in each of the asthma categories. We also investigated changes in the use of medications over time.

Multiple logistic regression was used to evaluate each potential risk factor while controlling for the effects of others. Tests for trend were performed using regression to assess changes over time.

RESULTS

Between 1998 and 2006, mothers of 5,323 nonmalformed infants in Massachusetts were located and approached for

Table 1. Rates of Asthma Among 3,609 Mothers of Nonmalformed Newborns

Asthma status	No. (%) of mothers
Physician diagnosed	502 (13.9)
Well controlled	153 (4.2)
Not well controlled	202 (5.6)
Poorly controlled	147 (4.1)
Possible	578 (16.0)
Past	137 (3.8)
No asthma	2,392 (66.3)

participation; 3,609 (67.8%) agreed to be interviewed. Overall, 502 women (13.9%) met our definition of physician-diagnosed asthma; an additional 578 (16.0%) were classified as having possible asthma and 137 (3.8%) as having past asthma (Table 1).

Physician-diagnosed asthma was most prevalent among the youngest women and decreased with age (Table 2). Higher prevalences were also observed among women who were white, were obese, had less than a high school education, smoked during pregnancy, and lived in households with 5 or

more members. Similarly, possible asthma was more prevalent among women who were young, were less well educated, and smoked during pregnancy, but, in contrast to physician-diagnosed asthma, possible asthma was most common among underweight women (body mass index [calculated as weight in kilograms divided by height in meters squared] <18.5) and was not associated with household size. Restricting participants to those with physician-diagnosed asthma (Table 3), women classified as having poorly controlled asthma tended to be older, to be less well educated, to smoke during preg-

Table 2. Prevalence of Asthma According to Selected Factors Among 3,609 Mothers of Nonmalformed Newborns^a

Factor	Physician-diagnosed asthma		Possible asthma		No asthma, No. (%)
	No. (%)	Adjusted OR ^b (95% CI)	No. (%)	Adjusted OR ^b (95% CI)	
Age, y					
≤24	126 (19.4)	1 [Reference]	110 (16.9)	1 [Reference]	391 (60.2)
25–29	122 (15.4)	0.7 (0.5–1.0)	116 (14.7)	0.9 (0.6–1.3)	512 (64.7)
30–34	149 (11.3)	0.5 (0.3–0.7)	214 (16.2)	1.0 (0.7–1.3)	917 (69.3)
≥35	103 (12.4)	0.5 (0.4–0.8)	137 (16.4)	1.0 (0.7–1.4)	565 (67.8)
Race/ethnicity					
White	418 (14.8)	1 [Reference]	468 (16.6)	1 [Reference]	1835 (65.1)
Black	23 (13.6)	0.8 (0.5–1.4)	28 (16.6)	1.1 (0.7–1.7)	106 (62.7)
Hispanic	48 (11.9)	0.6 (0.4–0.9)	63 (15.7)	0.9 (0.7–1.3)	272 (67.7)
Asian	6 (4.2)	0.2 (0.1–0.6)	13 (9.0)	0.5 (0.3–1.0)	119 (82.6)
Other	7 (9.2)	0.4 (0.2–0.9)	6 (7.9)	0.4 (0.2–0.9)	60 (78.9)
Body mass index					
Underweight	20 (13.4)	1.1 (0.6–1.8)	34 (22.8)	1.8 (1.2–2.8)	92 (61.7)
Normal weight	287 (12.9)	1 [Reference]	318 (14.3)	1 [Reference]	1540 (69.2)
Overweight	104 (13.9)	1.1 (0.8–1.5)	140 (18.7)	1.4 (1.1–1.7)	470 (62.8)
Obese	84 (19.8)	1.8 (1.3–2.3)	77 (18.2)	1.5 (1.1–2.0)	248 (58.5)
Education					
>High school	51 (18.1)	1.4 (0.9–2.1)	53 (18.8)	1.3 (0.9–1.9)	167 (59.2)
High school	227 (14.8)	1 [Reference]	260 (17.0)	1 [Reference]	981 (64.1)
Some college	224 (12.5)	1.1 (0.8–1.4)	265 (14.8)	1.0 (0.8–1.3)	1241 (69.2)
Smoking status					
Never	248 (12.2)	1 [Reference]	264 (13.0)	1 [Reference]	1448 (71.1)
Before pregnancy	132 (14.6)	1.3 (1.0–1.7)	151 (16.7)	1.4 (1.1–1.7)	592 (65.4)
During pregnancy	122 (18.3)	1.6 (1.2–2.2)	162 (24.3)	2.4 (1.9–3.2)	352 (52.9)
Caffeine consumption					
Never	172 (14.7)	1 [Reference]	183 (15.7)	1 [Reference]	773 (66.2)
Before pregnancy	141 (13.9)	0.9 (0.7–1.2)	168 (16.6)	1.0 (0.8–1.3)	664 (65.5)
During pregnancy	81 (15.0)	0.9 (0.7–1.3)	92 (17.0)	0.9 (0.7–1.3)	350 (64.8)
Alcohol consumption					
Never	219 (14.2)	1 [Reference]	241 (15.6)	1 [Reference]	1016 (65.8)
Before pregnancy	263 (13.6)	1.0 (0.8–1.2)	307 (15.9)	0.9 (0.8–1.3)	1301 (67.3)
During pregnancy	20 (15.0)	1.2 (0.7–2.1)	30 (22.6)	1.6 (1.0–2.6)	75 (56.4)
Income, \$					
<25,000	68 (16.8)	1.0 (0.7–1.5)	68 (16.8)	0.9 (0.7–1.4)	249 (61.6)
25,000–45,000	70 (15.2)	1.0 (0.7–1.4)	79 (17.2)	1.6 (1.0–2.6)	284 (61.7)
>45,000	305 (13.1)	1 [Reference]	368 (15.8)	1 [Reference]	1582 (67.8)
Household size					
1–2	178 (14.2)	1 [Reference]	189 (15.0)	1 [Reference]	830 (66.0)
3–4	230 (12.1)	0.9 (0.7–1.1)	316 (16.7)	1.1 (0.9–1.3)	1284 (67.8)
≥5	92 (20.6)	1.5 (1.1–2.0)	73 (16.3)	1.1 (0.8–1.5)	271 (60.0)

Abbreviations: CI, confidence interval; OR, odds ratio.

^a Percentages may not total 100 due to missing data.

^b Adjusted for all other factors in the table.

Table 3. Asthma Symptom Control According to Selected Factors Among 502 Mothers With Physician-Diagnosed Asthma^a

Factor	Poorly controlled asthma		Not well-controlled asthma		Well-controlled asthma, No. (%)
	No. (%)	Adjusted OR ^b (95% CI)	No. (%)	Adjusted OR ^b (95% CI)	
Age, y					
≤24	55 (43.7)	1 [Reference]	29 (23.0)	1 [Reference]	42 (33.3)
25–29	32 (26.2)	1.5 (0.7–3.4)	54 (44.3)	3.7 (1.6–8.7)	36 (29.5)
30–34	34 (22.8)	2.0 (0.8–5.0)	69 (46.3)	5.2 (2.2–12)	46 (30.9)
≥35	26 (25.2)	1.7 (0.7–4.2)	48 (46.6)	4.8 (1.9–12)	29 (28.2)
Race/ethnicity					
White	110 (26.3)	1 [Reference]	178 (42.6)	1 [Reference]	130 (31.0)
Black	12 (52.2)	2.2 (0.6–7.3)	6 (26.1)	1.1 (0.3–4.3)	5 (21.7)
Hispanic	21 (43.8)	0.6 (0.2–1.6)	12 (25.0)	0.5 (0.2–1.3)	15 (31.3)
Asian	1 (16.7)	2.3 (0.1–47)	4 (66.7)	1.5 (0.1–16)	1 (16.7)
Other	3 (42.9)	0.5 (0.1–4.8)	2 (28.6)	0.9 (0.1–7.6)	2 (28.6)
Body mass index					
Underweight	6 (30.0)	1.3 (0.3–5.3)	9 (45.0)	1.4 (0.4–5.3)	5 (25.0)
Normal weight	80 (27.9)	1 [Reference]	109 (38.0)	1 [Reference]	98 (34.1)
Overweight	37 (35.6)	1.5 (0.8–3.0)	40 (38.5)	1.4 (0.6–2.2)	27 (26.0)
Obese	21 (25.0)	0.8 (0.4–1.8)	41 (48.8)	1.1 (0.6–2.2)	22 (26.2)
Education					
>High school	20 (39.2)	1.3 (0.6–3.6)	19 (37.3)	1.9 (0.6–6.1)	12 (23.5)
High school	77 (33.9)	1 [Reference]	85 (37.4)	1 [Reference]	65 (28.6)
Some college	50 (22.3)	0.9 (0.5–1.7)	98 (43.8)	0.9 (0.5–1.6)	76 (33.9)
Smoking status					
Never	74 (29.8)	1 [Reference]	89 (35.9)	1 [Reference]	85 (34.3)
Before pregnancy	30 (22.7)	1.0 (0.5–1.9)	62 (47.0)	1.3 (0.7–2.2)	40 (30.3)
During pregnancy	43 (35.2)	1.5 (0.7–3.3)	51 (41.8)	1.7 (0.8–3.6)	28 (23.0)
Coffee consumption					
Never	57 (33.1)	1 [Reference]	63 (36.6)	1 [Reference]	52 (30.2)
Before pregnancy	47 (33.3)	1.3 (0.7–2.6)	48 (34.0)	1.1 (0.6–2.2)	46 (32.6)
During pregnancy	17 (21.0)	0.6 (0.2–1.3)	42 (51.9)	1.3 (0.6–2.4)	22 (27.2)
Alcohol consumption					
Never	68 (31.1)	1 [Reference]	103 (47.0)	1 [Reference]	48 (21.9)
Before pregnancy	75 (28.5)	0.7 (0.4–1.3)	89 (33.8)	0.3 (0.2–0.6)	99 (37.6)
During pregnancy	4 (20.0)	1.0 (0.2–4.3)	10 (50.0)	0.5 (0.1–1.6)	6 (30.0)
Income, \$					
<25,000	29 (42.6)	6.8 (2.3–20)	29 (42.6)	2.8 (1.0–8.0)	10 (14.7)
25,000–45,000	20 (28.6)	1.0 (0.5–2.2)	25 (35.7)	0.7 (0.2–1.5)	25 (35.7)
>45,000	71 (23.3)	1 [Reference]	133 (43.6)	1 [Reference]	101 (33.1)
Household size					
1–2	36 (20.2)	1 [Reference]	76 (42.7)	1 [Reference]	66 (37.1)
3–4	68 (29.6)	1.7 (1.0–3.1)	93 (40.4)	1.0 (0.6–1.7)	69 (30.0)
≥5	43 (46.7)	3.6 (1.6–8.3)	32 (34.8)	1.1 (0.5–2.7)	17 (18.5)

Abbreviations: CI, confidence interval; OR, odds ratio.

^a Percentages may not total 100 due to missing data.^b Adjusted for all other factors in the table.

nancy, to have lower family incomes, and to live in larger households than women with well-controlled asthma, although only the relationships with lower income and larger household size were statistically significant. Women in the not well-controlled category were more likely to be older than 24 years and in the lowest income group.

There was no significant trend over time in the prevalence of physician-diagnosed asthma, but the proportion of women with possible asthma decreased from 21% to 10% ($P < .001$) between 1997 and 2005 (data not shown).

The relationship between pregnancy and asthma symptoms varied considerably according to the degree of symptom control (Table 4). Although, overall, approximately half (53%) of women with physician-diagnosed asthma reported no change in symptoms, the proportion varied from 41% among those with poorly controlled asthma to 69% among those with well-controlled asthma. Those whose symptoms changed were almost equally divided between those who improved (24.6%) and those who worsened (22.4%). Women with poorly controlled asthma were more likely to report improvement (34.9%) than women

Table 4. Changes in Asthma Symptoms During Pregnancy

Change	Asthma control, No. (%)			Total, No. (%) (n = 492)
	Poorly controlled (n = 146)	Not well controlled (n = 196)	Well controlled (n = 150)	
No change	60 (41.0)	97 (49.5)	104 (69.3)	261 (53.0)
Symptoms improved				
Trimester 1	17 (11.6)	25 (12.8)	16 (10.7)	58 (11.8)
Trimester 2	25 (17.1)	8 (4.1)	8 (5.3)	41 (8.3)
Trimester 3	9 (6.2)	12 (6.1)	1 (0.7)	22 (4.5)
Total	51 (34.9)	45 (23.0)	25 (16.7)	121 (24.6)
Symptoms worsened				
Trimester 1	9 (6.2)	24 (12.2)	6 (4.0)	39 (7.9)
Trimester 2	17 (11.6)	15 (7.7)	6 (4.0)	38 (7.7)
Trimester 3	9 (6.2)	15 (7.7)	9 (6.0)	33 (6.7)
Total	35 (24.0)	54 (27.6)	21 (14.0)	110 (22.4)

with not well-controlled (23%) or well-controlled asthma (16.7%). Worsening of symptoms was almost equally likely to occur in any trimester (6.7%–7.9%), whereas improvement was noted somewhat more often in the first trimester (11.8% vs. 8.3% or 4.5%).

To consider rates of asthma medication use according to asthma status, we examined drugs reported by study participants to have been used for asthma (indication-based medication use); to capture use among women who had undiagnosed or unknown asthma (and therefore would not report medications use “for asthma”), we also examined drugs known to be used in the treatment of asthma (class-based medication use) (Table 5). For both drug groups, rates were highest among those with physician-diagnosed asthma, and within that category use decreased with better symptom control; there was little use among study participants with possible or past asthma. Of note, 63.3% of women whose asthma symptoms were poorly controlled did not use a controller medication during pregnancy. As expected, among women classified as not having asthma, none reported using a medication to treat asthma, although 4.1% reported use of a recognized asthma medication for other indications, such as colds or allergy.

To explore possible trends in the use of asthma medications over time, we restricted our analyses to women with physician-diagnosed asthma and investigated use according to year of LMP. Among the drug classes, no significant trends

were found in use of any asthma drug, any steroid, any β_2 -agonist, or any other asthma medication (Figure 1), and use of steroids by a specific route did not change significantly (Figure 2). Virtually all β_2 -agonist use was via inhalation.

According to lunar month of pregnancy, rates of use of inhaled steroids and β_2 -agonists were nearly constant for the period beginning 2 months before the LMP through the fourth lunar month. Inhaled steroid use decreased from 5% before pregnancy to 4.5%, and for β_2 -agonists the corresponding rates were 16% and 14% (data not shown).

Use of other asthma medications, including leukotriene modifiers and combination products (eg, fluticasone propionate and salmeterol), was generally low, but use of leukotriene modifiers increased consistently over time, and use of combination products increased significantly ($P = .007$), consistent with their recent introduction to the market (Figure 3).

The most commonly reported specific asthma medications were albuterol (53%), fluticasone (9.4%), beclomethasone (5.2%), and budesonide (3.0%). During the study years, only use of fluticasone changed significantly, from 2.4% to 8.4% ($P = .002$), perhaps because of its relatively recent introduction in 1997 (data not shown).

DISCUSSION

Asthma is recognized as one of the most common serious chronic conditions to complicate pregnancy,¹ with a preva-

Table 5. Use of Asthma Drugs Among 3,609 Mothers of Nonmalformed Newborns According to Asthma Status

Asthma status	Indication-based asthma medication use	Indication- or class-based asthma medication use	
		Use of at least 1 asthma medication	Use of ≥ 2 known asthma medications
Physician diagnosed	292 (58.2)	321 (63.9)	286 (57.0)
Poorly controlled (n = 147)	109 (74.1)	111 (75.5)	105 (71.4)
Not well controlled (n = 202)	121 (59.5)	140 (69.3)	122 (60.4)
Well controlled (n = 153)	62 (40.5)	70 (45.8)	59 (38.6)
Possible (n = 578)	0 (0.0)	50 (8.7)	19 (3.3)
Past (n = 137)	1 (0.7)	6 (4.4)	6 (4.4)
No asthma (n = 2392)	0 (0.0)	97 (4.1)	21 (0.9)

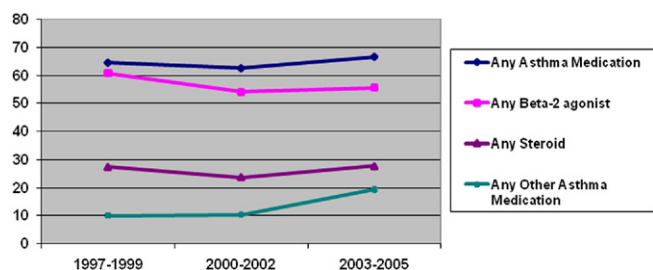


Figure 1. Trends in the use of asthma medications during pregnancy among 502 mothers with physician-diagnosed asthma.

lence estimated to range up to 8%, although 1 Australian study among women who had recently given birth reported a rate as high as 12.4%.¹⁴ We found that more than 14% of women in our study reported physician-diagnosed asthma. Although this is higher than previously reported,^{2,15,16} it may not be inconsistent with other observations. It is known that the prevalence of asthma increased through the 1990's,^{3,17,18} and because our data are derived from 1998-2006, the increasing prevalence may account in part for our higher rates. Also, the northeast region of the United States, and Massachusetts in particular, has among the highest reported rates in the general US population; in 2001, the Massachusetts rate of current asthma was 9.5 compared with the national average of 7.2.¹⁹

One novel aspect of this description of asthma in pregnancy is the attempt to include undiagnosed asthma. To do this, we relied not only on patient reports of physician-diagnosed asthma but also used self-reported symptoms to assess asthma status. Using responses to the questions developed to elicit information on symptoms, we estimated the overall prevalence of both physician-diagnosed and possible asthma. Responses to questions were also used to develop a scale of symptom control, and we believe the data on drug treatment for asthma provide indirect support for the validity of this scale. Although drug treatment (other than systemic steroids) was not an element of the symptom control classification, we found a strong inverse trend for increasing medication use according to degree of control. Although our questions measured control more than severity, the 2 con-

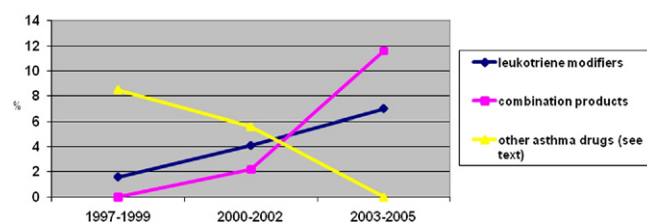


Figure 3. Trends in the use of selected asthma medications among 502 mothers with physician-diagnosed asthma.

structs are related, and there is an inverse relationship between severity and control.²⁰ Thus, we saw medication use increase as control decreased or severity increased, as would be expected. However, among women whose symptoms were poorly controlled, we found that almost two-thirds did not use controller medications, suggesting that asthma symptoms in pregnancy may be inadequately treated. We also found a strong relation between use of multiple drugs and level of asthma symptom control. As would be expected, among women with unrecognized asthma (possible asthma), none reported use of a medication to treat asthma; however, these women used asthma medications for what they considered to be other respiratory indications.

Many of the characteristics that we found to be positively associated with physician-diagnosed asthma among these pregnant women have been previously reported among asthmatic patients in general: race,^{3,21} education,²¹ income,²¹ and obesity²¹⁻²³; we also found asthma to be more common in larger households, a variable associated with socioeconomic status. The higher prevalence of smoking among asthmatic patients with poorly controlled disease (35%) was disturbing, given that the 2000 Joint Position Statement of the American College of Obstetrics and Gynecology, the American College of Asthma, Allergy, and Immunology, and the American Academy of Asthma, Allergy, and Immunology specifically identifies cigarettes as 1 of the asthma triggers to be avoided during pregnancy.²⁴ Higher smoking rates among asthmatic patients compared with nonasthmatic patients have been reported by others,^{14,25} suggesting that this may be an area for further education and intervention.

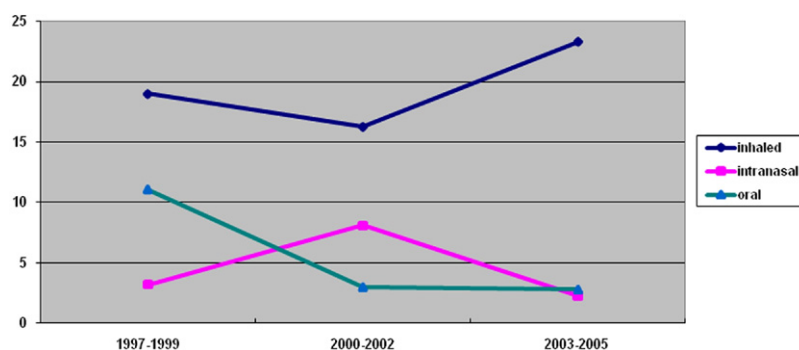


Figure 2. Trends in the use of corticosteroids during pregnancy among 502 mothers with physician-diagnosed asthma.

Several studies have reported that asthma symptoms remain stable during pregnancy for about a third of women, another third worsen, and the final third improve.^{26,27} Others have found that asthma is more likely to worsen in women with severe asthma.^{28,29} Our results may differ slightly because we considered only asthma symptoms, whereas others compared physiologic measurements or exacerbations.

One potential limitation of the current study is that objective measures of asthma status, such as pulmonary function, could not be used to confirm the self-reports. However, self-reported physician-diagnosed asthma has been shown to be a method of identifying patients with asthma in epidemiologic studies.³⁰

This study did not evaluate the risks to the fetus of asthma itself, but there appears to be general acceptance that uncontrolled asthma in pregnancy poses greater risks to the fetus than currently recommended asthma treatments.^{15,31,32} It is also widely recognized that there are insufficient data on the risks and safety of asthma medications in pregnancy.^{32–34} To provide guidance to health care professionals treating pregnant women with asthma, the NAEPP reviewed existing research and recommended what are considered to be effective and relatively safe treatments. Guidelines specifically for pregnancy were published in 1993,⁷ followed by a general update in 1997³⁵ and a pregnancy-specific update in 2005.¹ Since 1997, inhaled corticosteroids have been recommended as first-line therapy in pregnancy, yet we observed no substantial increase in inhaled corticosteroid use. This finding is consistent with data from the Slone Survey, a population-based survey of medication use in the United States^{36,37}; among women of child-bearing age interviewed between 1998 and 2005, use of inhaled steroids ranged from 1.9% in 1999 to 1.3% in 2006 (Judy Kelly, MS, written communication, September 12, 2006). It is possible that women might discontinue their use of inhaled steroids on learning that they are pregnant because of concerns for the fetus, and discontinued use of these medications in early pregnancy has been reported.³⁸ However, we saw little evidence of such a change when we compared use in the 2 months before pregnancy with use through the fourth lunar month of pregnancy.

In summary, this study confirms that asthma is a common condition in pregnant women in Massachusetts; we found that nearly 14% of mothers of nonmalformed newborns reported having been told by a health care professional that they had asthma within the 5 years before the pregnancy, and 50% of these reported using at least 1 medication for their asthma during pregnancy. An additional 16% reported symptoms consistent with asthma, and almost 10% of those were treated with an asthma medication. Given the NAEPP guidelines and the introduction of new medications, we expected to see appreciable changes in the drug management of asthma. Although we observed a small increase in use of inhaled steroids to 23%, it remains well below that of β_2 -agonists (50%–60%).

Leukotriene modifiers and combination drugs appear to have had little impact on the pharmacologic treatment of

asthma during pregnancy in the current study. Of concern, among women whose symptoms were poorly controlled, only approximately 37% reported use of controller medications, suggesting inadequate treatment of potentially severe asthma symptoms. These rates of asthma, asthma symptoms, and asthma medication use underscore the need to better understand the risks and safety of these medications in pregnancy, as well as the risks of asthma itself.

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Requests for reprints should be addressed to:
 Carol Louik, ScD
 Slone Epidemiology Center
 1010 Commonwealth Ave
 Boston, MA 02215
 E-mail: clouik@bu.edu

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