

ADHERENCE, CONTROL AND QUALITY OF LIFE

Asthma control, cost and race: results from a national survey

Laura S. Gold, PhD¹, Kai Yeung, MS, PharmD¹, Nancy Smith, MS², Felicia C. Allen-Ramey, PhD², Robert A. Nathan, MD³, and Sean D. Sullivan, PhD¹

¹Pharmaceutical Outcomes Research and Policy Program, School of Pharmacy, University of Washington, Seattle, WA, USA, ²Merck & Co., Inc, Whitehouse Station, NJ, USA, and ³Asthma and Allergy Associates, P.C. and Research Center, Colorado Springs, CO, USA

Abstract

Objective: Although interventions have been shown to alleviate symptoms in most patients suffering from asthma, only one-third of asthma patients have disease that is well-controlled. The purpose of this study is to investigate whether partly and uncontrolled asthmas are associated with increased costs for asthma-related healthcare utilization compared to well-controlled asthma and to determine whether these associations differed across racial groups. **Methods:** We classified respondents from the Asthma Insights and Management survey into those with well-, partly and uncontrolled asthma and compared utilization of healthcare services and costs among these groups, as well as between whites and non-whites. **Results:** Respondents categorized as having asthma that was not well-controlled reported lower income levels, higher rates of unemployment and more trouble paying for healthcare; similar results were found in analyses stratified by race. Patients whose asthma was partly or uncontrolled had greater use of asthma-related medications and medical services compared to patients whose asthma was well-controlled. Total unadjusted and adjusted costs were greater in patients whose asthma was classified as partly and uncontrolled. Similar results were found in analyses stratified on race. Across all levels of asthma control, non-whites had higher rates of utilization of emergency rooms and urgent care facilities and had greater rates of hospitalizations compared to whites. **Conclusions:** Our findings indicate that patients with asthma that is not well-controlled utilized more healthcare resources and had greater medical costs, despite lacking of health insurance which may suggest less access to care.

Keywords

Health insurance, hospitalization, income, oral steroids, urgent care

History

Received 17 January 2013

Revised 4 April 2013

Accepted 10 April 2013

Published online 12 June 2013

Introduction

Asthma increased in prevalence by approximately 12.3% between 2001 and 2009 in the United States [1]. Although medical interventions and environmental modifications in existence could likely prevent symptoms in most patients suffering from asthma, only about one-third of asthma patients are estimated to have well-controlled asthma [2–4]. Direct medical expenses for asthma are a significant burden, with an estimated \$50.1 billion spent on asthma-related costs in the U.S. in 2010 [1]. Asthma also contributes to indirect costs since patients with asthma have significantly more absenteeism from work, earn lower wages, and are more likely to be covered by Medicaid (state-funded U.S. health insurance for low-income families and individuals) compared to patients without asthma [5].

In the U.S., prevalence rates of asthma vary by race, with higher rates in blacks compared to whites, and by income, with higher rates in lower income populations [1]. Additionally, some populations such as blacks and Latinos have increased burden of asthma morbidity and mortality

compared to whites [6–8]. Increased rates of asthma morbidity and mortality have also been shown in populations with limited access to healthcare, such as populations with low-income levels and in census tracts with high-poverty rates [8–10]. The importance of this issue was recently highlighted by the creation of a task force, the Coordinated Federal Action Plan to Reduce Racial and Ethnic Asthma Disparities, that aims to implement clinical care guidelines and coordinate research to prevent asthma and reduce its severity among populations at risk [11].

To accommodate the recent emphasis on improving the quality of life, rather than physiological measurements, of asthma patients, the Global Initiative for Asthma (GINA) and the National Asthma Education Prevention Program (NAEPP) have published guidelines that focus on managing asthma symptoms in order to maintain normal daily activity levels [12,13]. In this paper, we defined groups of patients whose asthma was well-controlled, partly controlled, and uncontrolled (defined by GINA guidelines) [13] and examined associations between these levels of asthma control and direct medical costs. To make our results more applicable to asthma patients in international locations, we used the GINA, rather than the NAEPP, guidelines to define each level of asthma control. The purpose of this study was to investigate whether partly and uncontrolled asthmas were associated

Correspondence: Laura S. Gold, PhD, University of Washington, Box 359455, Seattle, WA 98195-9455, USA. Tel: +1 (206) 543-2749. Fax: +1 (206) 543-8609. E-mail: goldl@uw.edu

with increased costs for asthma medications as well as asthma-related utilization of healthcare services such as hospital admissions and emergency room visits compared to patients whose asthma was classified as well-controlled. In addition to analyzing these associations in our population as a whole, we also examined these relationships stratified on white versus non-white race.

Methods

This study was a retrospective, cross-sectional analysis of the Asthma Insights and Management (AIM) telephone survey conducted in 2009, the details of which have been outlined previously [14,15]. Briefly, subjects included 2500 asthma patients who were ≥ 12 years old sampled by random digit dialing of 60 682 U.S. households. The survey took an average of 33 min to complete and questions were answered by the adult who was most knowledgeable about that patient's asthma for subjects between 12 and 17 years old. Respondents/surrogates were defined as asthma patients and included in our dataset if they reported ever having been diagnosed with asthma, as well as either taking medication for their asthma or having had an asthma attack or asthma symptoms in the previous 12 months.

Because the AIM participants did not answer questions related to assessment of asthma control such as the Asthma Control Test, we used patients' answers (Supplementary table) to characterize respondents based on GINA guidelines [13] into three categories: well-controlled, partly controlled and uncontrolled asthma. The manifestations of asthma included daytime symptoms, restriction of daily activities, night-time symptoms and need for reliever/rescue treatment. We did not include the criteria of lung function measurement $< 80\%$ of predicted, because 66% of our sample had not received testing in the previous year.

Respondents to the survey provided data on the number of times they took oral steroids, inhalers for quick relief/rescue and long-term maintenance medications for management of asthma symptoms in the previous 12 months. They also reported the number of times they visited the emergency room, urgent care facilities or were hospitalized for asthma symptoms in the past 12 months. Direct health care costs for patients with an asthma diagnosis (ICD-9-CM, 493.01–493.02; 493.10–493.22; 493.90–493.92) between 1 January 2010 and 31 December 2010, were drawn from the Thomson Reuters MarketScan® Commercial Claims and Encounters (Ann Arbor, MI). National Drug Codes associated with oral steroids, inhalers for quick relief/rescue and long-term maintenance asthma medications were derived from the National Committee for Quality Assurance and supplemented using recent asthma clinical guidelines [16,17]. Mean annual costs in each therapeutic category were calculated by multiplying the mean cost per utilization by the number of instances of utilization in the previous 12 months reported by each AIM survey respondent. Mean costs of hospitalizations, emergency room visits and unscheduled visits to healthcare providers were similarly calculated. Finally, we totaled each participant's costs for all medications and instances of utilization to obtain the total mean annual direct costs of asthma care. The costs of the health services were standardized regardless of reported insurance status or out-of-pocket costs.

Frequencies and chi-square tests were calculated for demographic variables and measures of socioeconomic status (SES). Frequencies and chi-squared tests were calculated on SES variables stratified on white versus non-white race. Differences by level of asthma control in the number of instances of past 12 months-utilization of medications and healthcare services were examined and we used the Kruskal–Wallis tests to detect significance of these differences. We also calculated the differences between the number of instances of past 12 months utilization separately among white and non-white survey respondents and used *t*-tests to examine whether differences in instances of utilization were statistically significant between whites and non-whites. Next, we calculated unadjusted costs for the population as a whole and separately for white and non-white respondents and used *t*-tests to examine whether differences in total costs were statistically significant between whites and non-whites. We calculated adjusted costs using negative binomial regression, controlling for age, gender, race (white versus non-white), education, health insurance status (any versus none) and whether someone in the household smoked. Finally, we calculated adjusted costs, again using negative binomial regression, stratified on white and non-white race. Analyses were conducted using SAS Version 9.2 (SAS Institute, Inc, Cary, NC).

This study did not meet the federal definition of "human subject's research" and was exempt from Human Subjects review by the University of Washington Institutional Review Board.

Results

Seven respondents were missing data to calculate their level of asthma control, leaving 2493 asthma patients in our analysis population. Demographic characteristics of the respondents to the AIM survey, stratified on level of asthma control, are presented in Table 1. The majority of respondents to the survey (74%) had asthma that was classified as partly or uncontrolled. Being aged 40–64 years was associated with asthma that was classified as uncontrolled and female gender was also associated with uncontrolled asthma. Being black/African-American or American Indian/Alaska Native was also associated with uncontrolled asthma.

We observed several associations between measures of socioeconomic status and degree of asthma control. Having lower annual income was associated with asthma that was classified as partly or uncontrolled. Additionally, subjects/parents who owned their own homes and who were employed had higher rates of well-controlled asthma compared to subjects/parents who did not own their own homes or who were unemployed at the time of the survey. Having a high-school education or less was associated with asthma that was classified as uncontrolled. Finally, not having health insurance was associated with uncontrolled asthma compared to patients who did not have health insurance; similarly, having little or no trouble paying for health-related expenses was associated with well-controlled asthma. We found similar trends between markers of poverty and uncontrolled asthma when we examined measures of SES stratified by white versus non-white race (Table 2).

Table 1. Frequencies and chi-square results of descriptive variables of AIM survey respondents.

	All asthma patients (n = 2493)	Well-controlled (n = 638)	Partlycontrolled (n = 1093)	Uncontrolled (n = 762)	Chi-square p-value
Age					
12–17	314 (13%)	123 (19%)	143 (13%)	48 (6.3%)	
18–39	519 (21%)	152 (24%)	223 (20%)	144 (19%)	
40–64	1154 (46%)	250 (39%)	475 (43%)	429 (56%)	
65+	506 (20%)	113 (18%)	252 (23%)	141 (19%)	<0.0001
Male	764 (31%)	223 (35%)	341 (31%)	200 (26%)	
Female	1727 (69%)	415 (65%)	751 (69%)	561 (74%)	0.002
Race					
White	1903 (78%)	503 (80%)	851 (79%)	549 (74%)	
Non-white combined	539 (22%)	122 (20%)	227 (21%)	190 (26%)	0.01
Asian/Pac. Islander	47 (1.9%)	17 (2.7%)	19 (1.8%)	11 (1.5%)	
American Indian/Alaska native	76 (3.1%)	14 (2.2%)	30 (2.8%)	32 (4.3%)	
Black/African-American	292 (12%)	60 (9.6%)	126 (12%)	106 (14%)	
Hispanic	69 (2.8%)	15 (2.4%)	37 (3.4%)	17 (2.3%)	
Mixed race/other	55 (2.3%)	16 (2.6%)	15 (1.4%)	24 (3.3%)	0.003
Yearly income					
<\$15 000	444 (22%)	50 (10%)	178 (20%)	216 (34%)	
\$15 001–\$75 000	1013 (51%)	228 (47%)	468 (52%)	317 (50%)	
>\$75 000	548 (27%)	203 (42%)	250 (28%)	95 (15%)	<0.0001
Subject/parent owned home	1683 (69%)	480 (77%)	763 (71%)	440 (60%)	
Subject/parent did not own home	748 (31%)	143 (23%)	313 (29%)	293 (40%)	<0.0001
Subject/parent employed	1167 (53%)	375 (63%)	524 (53%)	268 (45%)	
Subject/parent unemployed	177 (8.1%)	32 (5.3%)	78 (7.8%)	67 (11%)	
Subject/parent not in labor force	843 (39%)	193 (32%)	393 (40%)	257 (43%)	<0.0001
Household member lost job in past year	466 (19%)	98 (16%)	203 (19%)	165 (22%)	
No household member lost job in past year	1990 (81%)	530 (84%)	882 (81%)	578 (78%)	0.01
Education: High school or less	963 (39%)	186 (30%)	390 (36%)	387 (52%)	
Some/completed college	1107 (45%)	302 (48%)	517 (48%)	288 (39%)	
Some/completed graduate school	385 (16%)	141 (22%)	176 (16%)	68 (9.2%)	<0.0001
Asthma patient had health insurance	2193 (89%)	593 (94%)	979 (90%)	621 (83%)	
Asthma patient did not have health insurance	274 (11%)	40 (6.3%)	105 (9.7%)	129 (17%)	<0.0001
Had little or no trouble paying health costs in past year	1759 (72%)	544 (87%)	781 (72%)	434 (58%)	
Had some or a lot of trouble paying health costs in past year	694 (28%)	82 (13%)	300 (28%)	312 (42%)	<0.0001

Next, we examined the mean number of times that respondents utilized asthma medications and healthcare services pertaining to their asthma, stratified on level of asthma control (Table 3). Patients whose asthma was characterized as partly or uncontrolled had greater numbers of uses of asthma medications (oral steroids, inhalers for quick relief/rescue and long-term maintenance medicines) as well as greater numbers of visits to the emergency room, other urgent care facilities and hospitalizations compared to patients whose asthma was well-controlled. We observed significant trends for all healthcare services across the levels of asthma control. We observed similar trends of greater medication use and healthcare utilization in respondents whose asthma was characterized as partly or uncontrolled compared to those with well-controlled asthma when we stratified our analyses on whites versus non-white race (Table 4). Additionally, respondents who were white reported significantly greater numbers of inhalers for quick relief/rescue medicine within each level of asthma control compared to non-whites (data not shown; p -value for well-controlled asthma: 0.01; partly controlled asthma: $p = 0.002$ and uncontrolled asthma: $p = 0.01$) but lower average utilization of emergency rooms (data not shown; p -value for well-controlled asthma: 0.05; partly controlled asthma: $p = 0.01$; uncontrolled asthma: $p = 0.01$). White asthma patients also reported fewer visits to urgent care facilities and fewer hospitalizations compared to respondents who were not white

but these differences were not statistically significant (data not shown).

Unadjusted and adjusted mean costs for utilization of asthma medications and healthcare services, stratified on level of asthma control, are presented in Table 5. In both unadjusted and adjusted analyses, we observed significant trends of increasing costs for decreasing level of asthma control with the exception of the adjusted costs for long-term maintenance medications. The greatest differences in absolute costs were observed for hospitalizations, with patients having well-controlled asthma with adjusted hospitalization costs that were less than 5% of the costs for patients with uncontrolled asthma (\$110 versus \$3060). Total adjusted costs for queried asthma-related medications and services for respondents whose asthma was classified as well-controlled were \$750 (95% CI: \$500–\$1100), compared to \$4140 (\$2860–\$6010) for respondents whose asthma was classified as uncontrolled. For the unadjusted costs, we observed similar trends of increasing costs with decreasing levels of asthma control, with the exception of long-term maintenance medications, when we stratified the analyses on respondents who were white and non-white (Table 6). Similar results were observed for adjusted costs stratified on white versus non-white race (Table 7). Differences in total costs were not significant between whites and non-whites with well-controlled asthma (\$830 versus \$650, respectively, $p = 0.36$), partly controlled asthma (\$1420 versus \$1960,

Table 2. Frequencies and chi-square results of socioeconomic status variables of aim survey respondents: stratified on white versus non-white race.

	White				Non-white			
	Well-controlled (n = 503)	Partlycontrolled (n = 851)	Uncontrolled (n = 549)	Chi-square p-value	Well-controlled (n = 122)	Partly-controlled (n = 227)	Uncontrolled (n = 190)	Chi-square p-value
Yearly income								
<\$15 000	32 (8.1%)	104 (15%)	142 (30%)		18 (21%)	71 (36%)	73 (46%)	
\$15 001–\$75 000	186 (47%)	384 (55%)	244 (52%)		41 (48%)	83 (42%)	71 (45%)	
>\$75 000	177 (45%)	208 (30%)	81 (17%)	<0.0001	26 (31%)	42 (21%)	14 (8.9%)	<0.0001
Subject/parent owned home	408 (82%)	646 (77%)	357 (66%)		67 (56%)	109 (49%)	80 (43%)	
Subject/parent did not own home	89 (18%)	197 (23%)	187 (34%)		53 (44%)	115 (51%)	105 (57%)	
Subject/parent employed	302 (63%)	420 (53%)	205 (47%)	<0.0001	68 (62%)	103 (53%)	62 (41%)	0.10
Subject/parent unemployed	19 (3.9%)	51 (6.5%)	38 (8.7%)		13 (12%)	26 (13%)	29 (19%)	
Subject/parent not in labor force	162 (34%)	317 (40%)	192 (44%)	<0.0001	29 (26%)	67 (34%)	59 (39%)	0.02
Household member lost job in past year	71 (14%)	157 (18%)	120 (22%)		25 (21%)	44 (20%)	44 (23%)	
No household member lost job in past year	432 (86%)	692 (82%)	428 (78%)		94 (79%)	181 (80%)	145 (77%)	
Education: completed high school or less	141 (28%)	281 (33%)	282 (51%)	0.005	42 (35%)	104 (46%)	102 (54%)	0.65
Some/completed college	244 (49%)	416 (49%)	212 (39%)		55 (46%)	99 (44%)	74 (39%)	
Some/completed graduate school	118 (23%)	151 (18%)	54 (10%)	<0.0001	22 (18%)	22 (9.8%)	13 (6.9%)	0.003
Asthma patient had health insurance	477 (95%)	772 (91%)	456 (84%)		106 (88%)	197 (88%)	152 (80%)	
Asthma patient did not have health insurance	25 (5.0%)	76 (9.0%)	89 (16%)		14 (12%)	28 (12%)	37 (20%)	0.07
Had little or no trouble paying health costs in past year	442 (89%)	613 (72%)	327 (60%)	<0.0001	94 (79%)	160 (71%)	102 (54%)	
Had some or a lot of trouble paying health costs in past year	56 (11%)	234 (28%)	216 (40%)	<0.0001	25 (21%)	64 (29%)	86 (46%)	<0.0001

Table 3. Means and standard deviations associated with past 12 months-use of asthma medications and healthcare services by level of control of asthma symptoms.

	Well-controlled n = 638		Partly controlled n = 1093		Uncontrolled n = 762	
	mean	(range)	mean	(range)	mean	(range)
Oral steroid (# of times taken in past year)	0.81	(0–50)	1.8	(0–90)	4.0	(0–96)
Inhaler for quick relief/rescue medicine (# per year)	0.95	(0–14)	2.3	(0–36)	6.9	(0–50)
Long-term maintenance medicine ^a (# fills per year)	3.83	(0–8.25)	3.99	(0–8.25)	4.5	(0–8.25)
Visits to emergency room (# times in past 12 months)	0.06	(0–4)	0.22	(0–20)	0.99	(0–36)
Hospitalization (# times in past 12 months)	0.03	(0–8)	0.07	(0–8)	0.50	(0–90)
Urgent care ^b (# times in past 12 months)	0.14	(0–12)	0.51	(0–12)	1.5	(0–50)

^aBased on how often they reported taking their long-term maintenance medication. Note that the maximum fills that respondents were able to report was 8.25.

^bUrgent care queried as ‘‘unscheduled emergency visits to a doctor’s office, clinic or somewhere else’’.

Table 4. Means and standard deviations associated with past 12 months-use of asthma medications and healthcare services by level of control of asthma symptoms stratified by white/non-white.

	White respondents				Non-white respondents			
	Well-controlled n = 503 mean (range)	Partly controlled n = 851 mean (range)	Uncontrolled n = 549 mean (range)	Kruskal-Wallis p-value	Well-controlled n = 122 mean (range)	Partly controlled n = 227 mean (range)	Uncontrolled n = 190 mean (range)	Kruskal-Wallis p-value
Oral steroid (# of times taken in past 12 months)	0.83 (0-50)	1.8 (0-90)	4.2 (0-96)	<0.0001	0.84 (0-50)	1.5 (0-36)	3.5 (0-90)	<0.0001
Inhaler for quick relief/rescue medicine (# in past 12 months)	1.0 (0-14)	2.5 (0-36)	7.4 (0-50)	<0.0001	0.67 (0-6)	1.7 (0-20)	5.3 (0-50)	<0.0001
Long-term maintenance medicine ^a (# fills in past 12 months)	4.0 (0-8.25)	4.2 (0-8.25)	4.6 (0-8.25)	0.10	3.0 (0-8.25)	3.0 (0-8.25)	4.2 (0-8.25)	0.02
Visits to emergency room (# times in past 12 months)	0.042 (0-4)	0.116 (0-6)	0.82 (0-36)	<0.0001	0.11 (0-2)	0.49 (0-20)	1.4 (0-20)	<0.0001
Hospitalization (# times in past 12 months)	0.028 (0-8)	0.053 (0-8)	0.47 (0-90)	<0.0001	0.033 (0-3)	0.12 (0-5)	0.53 (0-10)	<0.0001
Urgent care ^b (# times in past 12 months)	0.16 (0-12)	0.48 (0-12)	1.5 (0-50)	<0.0001	0.091 (0-2)	0.64 (0-12)	1.7 (0-30)	<0.0001

^aBased on how often they reported taking their long-term maintenance medication. Note that the maximum fills that respondents were able to report was 8.25.

^bUrgent care queried as “unscheduled emergency visits to a doctor’s office, clinic or somewhere else”.

Table 5. Costs of asthma medications’ use/healthcare services in previous 12 months by level of control of asthma symptoms.

	Unadjusted				Adjusted ^a			
	Mean cost of medication/health service (\$) ^b	Well-controlled mean \$ (range)	Partly-controlled mean \$ (range)	Uncontrolled mean \$ (range)	Kruskal-Wallis test p-value	Well-controlled mean \$ (95% CI)	Partly-controlled mean \$ (95% CI)	Uncontrolled mean \$ (95% CI)
Oral steroid (# times taken in past 12 months)	9.50	8.0 (0-470)	17 (0-850)	39 (0-910)	<0.0001	8.0 (4.2-16)	18 (9.1-37)	41 (19-86)
Inhalers for quick relief/rescue medicine (# in the past 12 months)	64	61 (0-890)	150 (0-2300)	440 (0-3190)	<0.0001	34.7 (22.5-53.4)	85.5 (57.1-128)	248 (165-372)
Long-term maintenance medicine (# of fills in the past 12 months) ^c	150	580 (0-1240)	610 (0-1240)	680 (0-1240)	0.03	330 (190-570)	350 (210-600)	440 (260-730)
Visits to emergency room (# times past 12 months)	340	19 (0-1362)	78 (0-6810)	330 (0-12,260)	<0.0001	28 (8.3-98)	100 (33-320)	430 (130-1350)
Hospitalizations (# times past 12 months)	11 270	330 (0-90 120)	760 (0-90 120)	4090 (0-225 300)	<0.0001	110 (6.0-2030)	690 (70-7050)	3060 (280-33 090)
Urgent care (# times past 12 months) ^d	61	9.0 (0-740)	32 (0-740)	96 (0-3070)	<0.0001	5.9 (2.6-14)	20 (9.1-43)	58 (26-130)
Total mean costs (\$, range)		790 (0-47 350)	1510 (0-60 050)	5240 (0-237 400)	<0.0001	750 (500-1110)	1360 (950-1960)	4140 (2860-6010)

^aAdjusted for age, gender, whether someone in the household smoked, race, education and insurance status.

^bMean costs for each medication/health service derived from Thomson Reuters MarketScan[®] databases.

^cCosts are based on the average cost per fill multiplied by the number of fills respondents were expected to need per year, based on how often they reported taking their long-term maintenance medication. Note that the maximum fills that respondents were able to report was 8.25.

^dUrgent care queried as “unscheduled emergency visits to a doctor’s office, clinic or somewhere else”.

Table 6. Unadjusted costs of asthma medications/healthcare services in previous 12 months by level of control of asthma symptoms; stratified by whites/non-whites.

	Mean cost of medication/health service (\$) ^a	Whites				Non-whites			
		Well-controlled mean \$ (range)	Partly-controlled mean \$ (range)	Uncontrolled mean \$ (range)	Kruskal-Wallis test <i>p</i> -value	Well-controlled mean \$ (range)	Partly-controlled mean \$ (range)	Uncontrolled mean \$ (range)	Kruskal-Wallis test <i>p</i> -value
Oral steroid (# times taken in past year)	9.50	7.9 (0–470)	18 (0–850)	40 (0–910)	<0.0001	8.2 (0–470)	14 (0–340)	34 (0–850)	<0.0001
Inhalers for quick relief/rescue medicine (# per year)	64	66 (0–890)	160 (0–2300)	480 (0–3190)	<0.0001	42 (0–380)	110 (0–1280)	330 (0–3190)	<0.0001
Long-term maintenance medicine (# of fills per year) ^b	150	610 (0–1240)	640 (0–1240)	690 (0–1240)	0.11	480 (0–1240)	470 (0–1240)	620 (0–1240)	0.07
Visits to emergency room (# times past 12 months)	340	14 (0–1360)	54 (0–2040)	280 (0–12,260)	<0.0001	38 (0–680)	170 (0–6810)	480 (0–6810)	<0.0001
Hospitalizations (# times past 12 months)	11 270	320 (0–90 120)	610 (0–90 120)	3450 (0–225 300)	<0.0001	390 (0–33,800)	1320 (0–56,330)	5940 (0–112,650)	<0.0001
Urgent care (# times past 12 months) ^c	61	9.8 (0–740)	29 (0–740)	92 (0–3070)	<0.0001	5.8 (0–120)	40 (0–740)	110 (0–1840)	<0.0001
Total mean costs (\$, range)		830 (0–47 350)	1420 (0–25 090)	4950 (0–237 400)	<0.0001	650 (0–12 860)	1960 (0–60 050)	6170 (0–48 680)	<0.0001

^aMean costs for each medication/health service derived from Thomson Reuters MarketScan[®] databases.

^bCosts are based on the average cost per fill multiplied by the number of fills respondents were expected to need per year, based on how often they reported taking their long-term maintenance medication. Note that the maximum fills that respondents were able to report was 8.25.

^cUrgent care queried as “unscheduled emergency visits to a doctor’s office, clinic or somewhere else”.

Table 7. Adjusted^a costs of asthma medications/healthcare services in previous 12 months by level of control of asthma symptoms; stratified by whites/non-whites.

	Mean cost of medication/health service (\$) ^b	Whites				Non-whites			
		Well-controlled mean \$ (95% CI)	Partly-controlled mean \$ (95% CI)	Uncontrolled mean \$ (95% CI)	<i>p</i> -value for trend	Well-controlled mean \$ (95% CI)	Partly-controlled mean \$ (95% CI)	Uncontrolled mean \$ (95% CI)	<i>p</i> -value for trend
Oral steroid (# times taken in past year)	9.50	6.2 (3.0–12.5)	14 (6.6–30)	33 (14–77)	<0.0001	9.1 (3.1–27)	19 (5.4–66)	56 (16–200)	0.0002
Inhalers for quick relief/rescue medicine (# per year)	64	55 (36–83)	130 (88–200)	360 (240–540)	<0.0001	31 (12–80)	79 (32–200)	270 (110–670)	<0.0001
Long-term maintenance medicine (# of fills per year) ^c	150	380 (220–650)	410 (250–690)	480 (280–810)	0.23	340 (110–990)	310 (100–960)	520 (180–1500)	0.27
Visits to emergency room (# times past 12 months)	340	9.0 (1.9–43)	34 (8.9–130)	160 (39–650)	<0.0001	53 (8.9–320)	300 (55–1600)	760 (140–4200)	0.0006
Hospitalizations (# times past 12 months)	11 270	320 (0–90 120)	610 (0–90 120)	3450 (0–225 300)	<0.0001	390 (0–33 800)	1320 (0–56 330)	5940 (0–112 650)	<0.0001
Urgent care (# times past 12 months) ^d	61	5.3 (2.2–13)	15 (6.4–37)	43 (18–110)	<0.0001	3.7 (0.8–17)	33 (9.1–120)	100 (27–370)	<0.0001
Total mean costs (\$, range)		640 (430–940)	1100 (770–1600)	3200 (2200–4700)	<0.0001	870 (370–2000)	2300 (1000–5400)	6600 (2800–16 000)	<0.0001

^aAdjusted for age, gender, whether someone in the household smoked, education, and insurance status.

^bMean costs for each medication/health service derived from Thomson Reuters MarketScan[®] databases.

^cCosts are based on the average cost per fill multiplied by the number of fills respondents were expected to need per year, based on how often they reported taking their long-term maintenance medication. Note that the maximum fills that respondents were able to report was 8.25.

^dUrgent care queried as “unscheduled emergency visits to a doctor’s office, clinic or somewhere else”.

respectively, $p = 0.31$), or uncontrolled asthma (\$4950 versus \$6170, $p = 0.38$).

Discussion

This study demonstrated that patients whose asthma is characterized as partly or uncontrolled use asthma-related medications and healthcare services at significantly greater rates and have significantly greater costs of care for their asthma compared to patients whose asthma is characterized as well-controlled. We also found that patients whose asthma was characterized as partly or uncontrolled were less likely to have higher income and education levels, have health insurance, or classify themselves as white compared to respondents with well-controlled asthma. Taken together, these findings indicate that patients with asthma that is not well-controlled utilize significantly greater asthma-related healthcare resources, despite the fact that they are more likely to have less access to care because they lack health insurance and are more likely to have lower socioeconomic status compared to patients with well-controlled asthma.

Several previous studies have examined the relationship between medical costs and level of asthma control using different methods of classification of asthma control. Szeffler et al. examined costs associated with level of impairment from asthma in children using the 2007 NAEPP guidelines to characterize degree of asthma control [18]. Similar to our findings, they found that costs associated with hospitalizations, emergency department visits and asthma-related medications, as well as total mean costs, were greatest in patients whose asthma was very poorly controlled [18]. A study in Italy assigned asthma symptom scores to each of its participants and evaluated the association between these scores and medical costs [19]. They found that patients whose asthma was poorly controlled had more than three times the costs compared to patients whose asthma was well-controlled and, though patients in the poorly controlled category accounted for only 25% of the population, they accounted for over half of the costs due to hospitalization. Finally, a paper by Sullivan et al. compared costs among patients with controlled and uncontrolled asthma, characterized using guidelines from the Gaining Optimal Asthma Control (GOAL) study [20] and found that costs for patients whose asthma was uncontrolled were more than twice the costs for patients whose asthma was controlled [21].

Many studies have shown relationships between markers of reduced socioeconomic status such as low income or lack of health insurance and increased prevalence and severity of asthma [22–24]. We found non-whites with partly and uncontrolled asthma tended to have greater utilization rates of health services and incur greater costs compared to whites. Across all levels of asthma control, we also found that non-whites tended to have higher rates of utilization of emergency rooms and urgent care facilities and had greater rates of hospitalizations compared to whites, indicating that they might be more likely to depend on these sources, rather than non-urgent office visits, for their primary care.

Additionally, rates of asthma diagnoses and severity have been shown to be higher among African-Americans and Latinos, especially those residing in inner-city urban areas,

compared to other races and ethnicities [25,26]. While the causes of these disparities are likely complex, the fact that our study showed that poorly controlled asthma was highly associated with both indicators of poverty and with the largest economic burden is troubling because, among those with access to quality healthcare, medications and environmental modifications have been shown to be effective at bringing asthma symptoms under control [27–29]. Even among high-risk populations (including those with low incomes, Latinos and African-Americans, and/or populations without health insurance) with persistent asthma symptoms, intensive interventions have the potential to control asthma for a majority of patients [30,31]. Successful interventions geared specifically at controlling asthma symptoms in non-white and low-socioeconomic status populations would likely have a large impact on the economic burden of asthma in the United States.

Although our study included a large, randomly selected population and was the first to utilize GINA guidelines to examine associations between healthcare costs and level of asthma control, it had several limitations. Because we did not have data on non-respondents, we cannot be sure that those who agreed to take part in the survey were representative of the U.S. population of asthma patients and results of this analysis might not be generalizable. Although the survey questions were standardized across interviewers, terms used in the questionnaire might have been subject to interpretation and responses between participants might not be comparable. A minor limitation is that although the survey was conducted in 2009, we only had access to 2010 cost data, but since these costs were applied consistently to all levels of asthma control, we do not expect that this limitation affected our conclusions. Also, not all costs that asthma patients would have been expected to incur was included in the questionnaire. For example, we did not have data on the number of times patients visited physicians or specialists, and thus could not include those costs in our calculations. We also did not include indirect costs such as absenteeism from work/school or reduced productivity in our comparisons across the varying levels of asthma control. Although the wording of the survey questions that we used to define well-controlled, partly controlled and uncontrolled asthma was similar to that used in the GINA guidelines (see Supplementary table), it did not correlate perfectly and most of our study population did not provide information on FEV1 so we were not able to use that information in our classifications. Also, our analyses were based on self-reported information which may have been biased. Additionally, because one purpose of this study was to generate hypotheses, we did not oversample asthma patients whose race was other than white. Future research should focus on sampling non-white populations to further investigate associations between race and asthma-related costs and healthcare utilization. Finally, while this paper reports associations between poorly controlled asthma and healthcare costs, the data were cross-sectional and thus, we cannot address issues of causality in this study.

Conclusions

Using a large population of the U.S. asthma patients, this study demonstrated that the healthcare costs of asthma that

was not well-controlled were substantial. In addition, poorly controlled asthma was strongly associated with indicators of low socioeconomic status. We found similar associations when we examined costs and indicators of low socioeconomic status in whites and non-whites separately, indicating that lack of asthma control results in a substantial burden to the U.S. healthcare system beyond simple racial identifications. Steps to achieve control over asthma symptoms, especially among patients belonging to communities that lack access to quality care, would significantly reduce the clinical and economic burden of asthma in the U.S.

Declaration of interest

This work was sponsored by a grant to the University of Washington from Merck & Co., Inc. The authors do not have any financial, consulting or personal relationships with people or organizations that could influence this work.

References

- Vital signs: asthma prevalence, disease characteristics, and self-management education: United States, 2001–2009. *MMWR Morb Mortal Wkly Rep* 2011;60:547–52.
- Cazzoletti L, Marcon A, Janson C, et al. Asthma control in Europe: a real-world evaluation based on an international population-based study. *J Allergy Clin Immunol* 2007;120:1360–7.
- Sadatsafavi M, Lynd L, Marra C, et al. Direct health care costs associated with asthma in British Columbia. *Can Respir J* 2010;17: 74–80.
- Nguyen K, Zahran H, Iqbal S, et al. Factors associated with asthma control among adults in five New England states, 2006–2007. *J Asthma* 2011;48:581–8.
- Sullivan PW, Ghushchyan VH, Slejko JF, et al. The burden of adult asthma in the United States: evidence from the Medical Expenditure Panel Survey. *J Allergy Clin Immunol* 2011;127: 363–9.
- Ramsey CD, Celedon JC, Sredl DL, et al. Predictors of disease severity in children with asthma in Hartford, Connecticut. *Pediatr Pulmonol* 2005;39:268–75.
- Simon PA, Zeng Z, Wold CM, et al. Prevalence of childhood asthma and associated morbidity in Los Angeles County: impacts of race/ethnicity and income. *J Asthma* 2003;40:535–43.
- Flores G, Snowden-Bridon C, Torres S, et al. Urban minority children with asthma: substantial morbidity, compromised quality and access to specialists, and the importance of poverty and specialty care. *J Asthma* 2009;46:392–8.
- McCoy L, Redelings M, Sorvillo F, Simon P. A multiple cause-of-death analysis of asthma mortality in the United States, 1990–2001. *J Asthma* 2005;42:757–63.
- Schleicher NC, Koziol JA, Christiansen SC. Asthma mortality rates among California youths. *J Asthma* 2000;37:259–65.
- Environmental Protection Agency. Coordinated Federal Action Plan to Reduce Racial and Ethnic Asthma Disparities. 2012 [updated 31 May 2012; cited 2012 June 4]; Available from: <http://www.epa.gov/childrenstraskforce/index.html>
- National Asthma Education and Prevention Program (NAEPP) Coordinating Committee. Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma. National Asthma Education and Prevention Program (NAEPP), 2007 20 Dec 2011. Report No 3; Available from: <http://www.nhlbi.nih.gov/guidelines/asthma/asthgdln.pdf>
- Global Initiative for Asthma (GINA). Pocket Guide for Asthma Management and Prevention (for Adults and Children Older than 5 Years). 2010.
- Meltzer EO, Blaiss MS, Nathan RA, et al. Asthma burden in the United States: results of the 2009 Asthma Insight and Management survey. *Allergy Asthma Proc* 2012;33:36–46.
- Murphy KR, Meltzer EO, Blaiss MS, et al. Asthma management and control in the United States: results of the 2009 Asthma Insight and Management survey. *Allergy Asthma Proc* 2012;33:54–64.
- Kim SH, Kim TW, Kwon JW, et al. Economic costs for adult asthmatics according to severity and control status in Korean tertiary hospitals. *J Asthma* 2012;49:303–9.
- Wallihan DB, Stump TE, Callahan CM. Accuracy of self-reported health services use and patterns of care among urban older adults. *Med care* 1999;37:662–70.
- Szeffler SJ, Zeiger RS, Haselkorn T, et al. Economic burden of impairment in children with severe or difficult-to-treat asthma. *Ann Allergy Asthma Immunol* 2011;107:110–19.e1.
- Accordini S, Bugiani M, Arossa W, et al. Poor control increases the economic cost of asthma. A multicentre population-based study. *Int Arch Allergy Immunol* 2006;141:189–198.
- Bateman ED, Boushey HA, Bousquet J, et al. Can guideline-defined asthma control be achieved? The Gaining Optimal Asthma Control study. *Am J Respir Crit Care Med* 2004;170:836–44.
- Sullivan SD, Rasouliyan L, Russo PA, et al. Extent, patterns, and burden of uncontrolled disease in severe or difficult-to-treat asthma. *Allergy* 2007;62:126–33.
- Curtis LM, Wolf MS, Weiss KB, Grammer LC. The impact of health literacy and socioeconomic status on asthma disparities. *J Asthma* 2012;49:178–83.
- Kanervisto M, Vasankari T, Laitinen T, et al. Low socioeconomic status is associated with chronic obstructive airway diseases. *Respir Med* 2011;105:1140–6.
- Bacon SL, Bouchard A, Loucks EB, Lavoie KL. Individual-level socioeconomic status is associated with worse asthma morbidity in patients with asthma. *Respir Res* 2009;10:125.
- Bryant-Stephens T. Asthma disparities in urban environments. *J Allergy Clin Immunol* 2009;123:1199–206; quiz 1207–1198.
- Lang DM, Polansky M, Sherman MS. Hospitalizations for asthma in an urban population: 1995–1999. *Ann Allergy Asthma Immunol* 2009;103:128–33.
- Najada A, Abu-Hasan M, Weinberger M. Outcome of asthma in children and adolescents at a specialty-based care program. *Ann Allergy Asthma Immunol* 2001;87:335–43.
- Jones CA, Clement LT, Morpew T, et al. Achieving and maintaining asthma control in an urban pediatric disease management program: the Breathmobile Program. *J Allergy Clin Immunol* 2007;119:1445–53.
- Szeffler SJ. Advancing asthma care: the glass is only half full! *J Allergy Clin Immunol* 2011;128:485–94.
- Szeffler SJ, Gergen PJ, Mitchell H, Morgan W. Achieving asthma control in the inner city: do the National Institutes of Health Asthma Guidelines really work? *J Allergy Clin Immunol* 2010;125: 521–6; quiz 527–8.
- Scott L, Morpew T, Bollinger ME, et al. Achieving and maintaining asthma control in inner-city children. *J Allergy Clin Immunol* 2011;128:56–63.