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Air Quality Awareness Among U.S. Adults With Respiratory and Heart Disease

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Abstract

Introduction—Poor air quality affects respiratory and cardiovascular health. Information about health risks associated with outdoor air quality is communicated to the public using air quality alerts. This study was conducted to assess associations of existing respiratory and heart disease with three aspects of air quality awareness: awareness of air quality alerts, discussing with a health professional strategies to reduce air pollution exposure, and avoiding busy roads to reduce air pollution exposure when walking, biking, or exercising outdoors.

Methods—During 2014–2016, a total of 12,599 U.S. adults participated in summer waves of the ConsumerStyles surveys and self-reported asthma, emphysema/chronic obstructive pulmonary disease, heart disease, and each aspect of air quality awareness. In 2017, associations between each health condition and air quality awareness were estimated using log binomial and multinomial regression.

Results—Overall, 49% of respondents were aware of air quality alerts, 3% discussed with a health professional strategies to reduce air pollution exposure, and 27% always/usually avoided busy roads to reduce air pollution exposure. Asthma was associated with increased prevalence of awareness of air quality alerts (prevalence ratio=1.11, 95% CI=1.04, 1.20), discussing with a

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health professional (prevalence ratio=4.88, 95% CI=3.74, 6.37), and always/usually avoiding busy roads to reduce air pollution exposure (prevalence ratio=1.13, 95% CI=1.01, 1.27). Heart disease was not associated with air quality awareness.

Conclusions—Existing respiratory disease, but not heart disease, was associated with increased air quality awareness. These findings reveal important opportunities to raise awareness of air quality alerts and behavior changes aimed at reducing air pollution exposure among adults at risk of exacerbating respiratory and heart diseases.

INTRODUCTION

The impact of outdoor air quality on respiratory and cardiovascular health is well established.[1–5] Exposure to ambient air pollution affects asthma,[6] school absences because of asthma,[7] emergency department visits and hospital admissions for respiratory and cardiovascular diseases,[5,8,9] and cardiopulmonary mortality.[10–13] Information about air quality and its associated health risks is communicated to the public using air quality alerts, such as the U.S. Environmental Protection Agency's Air Quality Index.[14] The Air Quality Index is a six-category index that uses daily and local measurements of air pollutants to identify air quality conditions that range from good, when air quality poses little or no health risk, to hazardous, when air quality is likely to cause serious health effects.[14,15] Air quality alerts, such as the Air Quality Index, are used to inform the public when air quality is likely to affect sensitive populations, including people with heart or lung disease.[15]

Broadly speaking, the effectiveness of air quality alerts depends on the extent to which individuals in sensitive populations are aware of the alerts and take action to reduce their exposures to poor air quality. Estimates of the proportion of the populations aware of air quality alerts range from one third in the general population[16] to 95% among parents seeking care for a child with asthma.[17] By contrast, only small fractions of the population report changing behaviors during episodes of poor air quality.[18,19] For example, data from the National Health and Nutrition Survey Examination indicate that 12% of adults reported doing something differently (e.g., spending less time outdoors, closing windows) because of poor air quality.[18] Older adults, women, those with more education, and adults with respiratory or cardiovascular conditions were more likely report such an activity change.[18] However, findings from qualitative research indicate that individuals with asthma or cardiovascular disease do not necessarily change their behaviors in response to air quality alerts (Scott A. Damon, unpublished observations, 2016).

Because of the well-recognized impact of air pollution on the health of individuals with pre-existing respiratory and heart disease, there is a need to better understand awareness of air quality alerts and specific actions taken, especially by at-risk individuals, to reduce air pollution exposure. The aim of this study is to assess associations of respiratory and heart disease with awareness of air quality alerts, discussing, with a health professional strategies to reduce air pollution exposure, and avoiding busy roads to reduce air pollution exposure.

METHODS

Data from the summer 2014–2016 waves of the ConsumerStyles surveys conducted by the public relations firm Porter Novelli Public Services were used. Each year, ConsumerStyles surveys are conducted as cross-sectional surveys of a random sample of adults from KnowledgePanel®, an Internet panel of ≅55,000 men and women aged ≥18 years. Sampling is probability-based to be representative of the U.S. adult population. Additional details about the survey are available elsewhere.[20–22] From 2014 through 2016, the summer waves of the ConsumerStyles surveys (hereafter referred to as SummerStyles) were conducted among the sample of adults who responded to the spring waves of the ConsumerStyles surveys (i.e., SpringStyles). Analysis of ConsumerStyles data is exempt from IRB review at the Centers for Disease Control and Prevention.

Study Population

These analyses included data collected in 2014, 2015, and 2016 from 12,599 adults aged 18–94 years. In 2014, the SpringStyles survey was sent to 11,018 potential respondents and completed by 6,713 (61%). Between June 13 and July 7, 2014, SummerStyles was completed by 4,269 (69%) of 6,159 SpringStyles respondents. In 2015, the SpringStyles survey was sent to 11,028 potential respondents and completed by 6,836 (62%). Between June 11 and June 29, 2015, SummerStyles was completed by 4,127 (67%) of 6,172 SpringStyles respondents. In 2016, the SpringStyles survey was sent to 10,955 potential respondents and completed by 6,490 (59%). Between June 24 and July 11, 2016, SummerStyles was completed by 4,203 (68%) of 6,166 SpringStyles respondents.

Measures

Respondents reported health conditions by responding to a single questionnaire item: *During the past year, have you had (or do you currently have) any of these health conditions?* Response options consisted of a list of health conditions, including *asthma*, *emphysema/chronic obstructive pulmonary disease (COPD)*, *atrial fibrillation*, *congestive heart failure*, and *other heart disease (angina or heart attack)*. For each condition, respondents with positive responses were categorized as having the condition within the past year. Respondents who reported atrial fibrillation, congestive heart failure, or other heart disease (angina or heart attack) were categorized as having heart disease; respondents with negative responses to all three conditions were categorized as not having heart disease.

Questionnaire items about air quality were framed using the following statement, *The next few questions are about air quality. The government routinely collects and distributes information on air quality to help inform the public about air pollution levels.* Respondents then answered three questions to determine whether they (1) were aware of air quality alerts (*Have you ever heard or read about the Air Quality Index or air quality alerts where you live?*; response options: *yes*, *no*, *don't know*); (2) discussed with a health professional strategies to reduce air pollution exposure (*Have you and your doctor, nurse, or other health professional ever talked about what to do differently when air quality is bad?*; response options: *yes*, *no*, *don't know*); and (3) avoided busy roads to reduce air pollution exposure (*When walking, biking, or exercising outdoors, how often do you avoid busy roads to reduce*

your exposure to air pollution?; response options: *always*, *usually*, *sometimes*, *rarely*, *never*, *don't know*). For each question, negative (i.e., no, never) and uninformative responses (i.e., don't know, missing) were categorized as negative. Survey questions about awareness of air quality alerts and discussing with a health professional were selected and modified, as necessary, from an existing population-based survey.[19] The survey question about avoiding busy roads was developed specifically for this survey. Awareness of air quality alerts, discussing with a health professional strategies to reduce air pollution exposure, and avoiding busy roads to reduce air pollution exposure are hereafter collectively referred to as "air quality awareness."

Statistical Analysis

Because SummerStyles was designed to be representative of the U.S. adult population, Porter Novelli Public Services proportionally weighted the data to match U.S. Current Population Survey proportions of four characteristics of the respondents (i.e., age, educational attainment, race/ethnicity, and sex) and five household characteristics (i.e., Census region, household income, household size, metropolitan status, and prior Internet access).

These data were analyzed in 2017. Data from the three survey years were pooled and analyzed as a single, pooled sample. All analyses were weighted using survey weights provided with the data. Descriptive analyses were conducted using SAS, version 9.3 to examine distributions of demographic characteristics, air quality awareness, and health status. Associations of respiratory and heart disease with awareness of air quality alerts and discussing with a health professional strategies to reduce air pollution exposure were estimated using log binomial regression. Because responses to the questionnaire item about avoiding busy roads to reduce air pollution exposure were categorized into three response categories (always/usually, sometimes/rarely, never), associations with avoiding busy roads were estimated using multinomial log regression. All regression analyses were conducted using SAS-callable SUDAAN, version 11. The regression models were used to generate adjusted prevalences of air quality awareness and associations, presented as prevalence ratios (PR) with 95% CIs. Adjusted PRs were generated using models controlled for age, educational attainment, race/ethnicity, sex, smoking status, and survey year using the categories shown in Table 1. The 45 respondents for whom smoking status was not reported were categorized as lifetime nonsmokers.

RESULTS

Demographic characteristics and respiratory and heart disease status of the respondents are shown in Table 1. The average age of respondents was 46.8 years (SD=17.4 years, range, 18–94 years). Overall, 6.9% reported having asthma, 2.3% reported having emphysema/COPD, and 3.4% reported having heart disease. There was little overlap between the three conditions, with 0.7% of the population (n=95) reporting asthma and emphysema/COPD, 0.5% (n=48) reporting asthma and heart disease, and 0.6% (n=73) reporting emphysema/COPD and heart disease. Of the 12,599 respondents, 49.2% were aware of air quality alerts where they live, 3.0% had discussed with a health professional strategies to reduce air

pollution exposure, and 27.3% always/usually avoided busy roads to reduce their air pollution exposure when walking, biking, or exercising outdoors.

The percentage of adults aware of air quality alerts increased with increasing age and educational attainment and was highest among white, non-Hispanic respondents (54.9%, 95% CI=53.7, 56.1), higher among men than women (52.6%, 95% CI=51.1, 54.1 vs 46.0%, 95% CI=44.6, 47.4, respectively), and higher among former smokers (52.3%, 95% CI=50.5, 54.2) and lifetime non-smokers (49.1%, 95% CI=47.7, 50.5) than current smokers (43.5%, 95% CI=40.7, 46.2; Table 2). The percentage of adults who reported always/usually avoiding busy roads to reduce air pollution exposure generally followed similar patterns across categories of age and smoking status; however, more variation was observed across categories of educational attainment and race/ethnicity and the percentage was higher among women than men. The numbers of respondents who discussed with a health professional strategies to reduce air pollution exposure were low and no clear patterns were identified in the percentages across demographic categories.

Weighted percentages reporting the three aspects of air quality awareness and unadjusted PRs are shown in Table 3. In adjusted models, asthma was associated with increased prevalence of awareness of air quality alerts (PR=1.11, 95% CI=1.04, 1.20), discussing with a health professional strategies to reduce air pollution exposure (PR=4.88, 95% CI=3.74, 6.37), and always/usually avoiding busy roads to reduce air pollution exposure (PR=1.13, 95% CI=1.01, 1.27; Table 4). Emphysema/COPD was positively associated with discussing with a health professional strategies to reduce air pollution exposure (PR=3.31, 95% CI=2.21, 4.95). Heart disease was not associated with awareness of air quality alerts, discussing with a health professional strategies to reduce air pollution exposure, or always/usually avoiding busy roads to reduce air pollution exposure. Heart disease was, however, positively associated with never avoiding busy roads to reduce air pollution exposure (PR=1.14, 95% CI=1.03, 1.27).

DISCUSSION

These data show that awareness of air quality alerts, discussing with a health professional strategies to reduce air pollution exposure, and taking action to reduce air pollution exposure by avoiding physical activity on busy roads are more common among adults with respiratory diseases than among adults without respiratory diseases. These findings support existing evidence that adults with asthma are not only more aware of, but also more likely to change their outdoor activities because of, media alerts about air quality than adults without asthma.[19] In this study, emphysema/COPD was positively associated with discussing with a health professional strategies to reduce air pollution exposure, whereas heart disease was only associated with never avoiding busy roads to reduce air pollution exposure. Taken together, these findings broaden the available information about the extent to which targeting messages about air quality may raise awareness about air quality alerts and motivate behavior changes to reduce air pollution exposure among adults at risk of exacerbations during periods of unhealthy air quality.

The SummerStyles data are weighted to reflect the U.S. population of adults and the weighted prevalences of asthma (6.9%) and heart disease (3.4%) reported from these data are similar to estimates of these conditions from other nationally representative data sources. In 2015, for example, among U.S. adults aged 18 years and older, the prevalence of asthma was estimated to be 7.6%[23] and the prevalence of coronary heart disease was estimated to be 3.7%.[24] Regarding air quality awareness, weighted results indicate that 49% of the U.S. population of adults are aware of air quality alerts where they live, 3% have discussed with a healthcare professional strategies to reduce air pollution exposure, and 27% always/usually avoid busy roads to reduce air pollution exposure when walking, biking, or exercising outdoors. Previous epidemiologic research reveals distinct challenges involved in using air quality alerts to trigger changes in behavior. In 2008, Semenza et al.[16] reported that air quality alerts were not effective in changing adults' behaviors and that when behavior changes did occur they were more often motivated by perceptions of poor air quality than by air quality alerts. The observed variations in awareness of air quality alerts and avoiding busy roads to reduce air pollution exposure across categories of age, educational attainment, and other demographic traits, as well as across categories of health status, suggest that targeted interventions might improve awareness of air quality alerts and willingness to make changes during periods of poor air quality.

These analyses include data collected over 3 years. Increases from 2014 to 2016 in percentages of the entire population that were aware of air quality alerts and that always/usually avoided busy roads to reduce air pollution exposure were modest and not statistically significant at $\alpha=0.05$ (data not shown), but nonetheless suggest increases over time toward more air quality awareness. By contrast, the low percentages and minimal variation across demographic characteristics and over time in discussing with a health professional strategies to reduce air pollution exposure (data not shown) suggest that interventions aimed at increasing knowledge and changing behaviors among health professionals are warranted.

For these analyses, data collected over three cycles of SummerStyles surveys were pooled together. This analytic decision increased the size of the analytic sample, decreased the magnitudes of the errors associated with estimates of prevalence, and eased interpretation of the results by presenting a single result for each exposure–outcome association. Indeed, there was little variation in the estimates across the 3 years; however, this analytic approach precludes presenting results that provide information about trends in air quality awareness over time. Similarly, because these analyses included data pooled from 3 survey years, respondents who completed the survey in 2 or more years were included in the final population more than once. As a result, responses provided by the 1,658 (16%) respondents who participated in two of the three surveys and the 380 (4%) who participated all 3 years are not independent. Because the data were weighted to reflect the distribution of the U.S. population on nine individual- and household-level factors, duplicate respondents could not be removed while preserving the representativeness of the sample. Examining correlations in responses provided by those who participated in 2 years revealed higher correlations between repeated questions about health status (asthma: $\rho=0.77$; emphysema/COPD: $\rho=0.72$; heart disease: $\rho=0.56$) than between repeated questions about air quality awareness (awareness of air quality alerts: $\rho=0.47$; discussing with a health professional: $\rho=0.23$; avoiding busy: $\rho=0.43$). The correlation coefficients for air quality awareness responses do

not suggest that these findings are affected by highly correlated data, but do suggest that air quality awareness varies over time. Efforts to improve air quality awareness among sensitive populations likely need to include periodic or ongoing public health messages, rather than a one-time message.

For this study, heart disease was defined using responses to questionnaire items about having atrial fibrillation, congestive heart failure, and other heart disease. Ideally, a broad definition of heart disease would also include having a history of coronary artery disease, bypass surgery or angioplasty, an internal cardiac defibrillator, a stroke or transient ischemic attack, and blockages in the arteries of the neck and legs. Collectively, these conditions represent those with known heart disease who are at risk of adverse outcomes because of poor air quality. Because these conditions were not included in the questionnaire, the findings presented might not be representative of air quality awareness in the population with these other aspects of heart disease. Nonetheless, these results—in particular, the finding that heart disease was associated with never avoiding busy roads to reduce air pollution exposure—highlight an opportunity for raising awareness about air quality and its potential health effects among people with known heart disease.

These findings reveal important opportunities for preventing exacerbations among adults with respiratory and heart disease. For example, efforts to improve asthma control could include increasing awareness about air quality, air quality alerts, the health impacts of exposure to poor air quality, and changes in behaviors that may reduce exposures during episodes of poor air quality. Similarly, Million Hearts®, a national initiative to prevent one million heart attacks and strokes over 5 years, provides an opportunity to increase air quality awareness among people with heart disease. Messages raising awareness about the impact of poor air quality on people with known heart disease, how to receive air quality alerts, and how to change behaviors based on alerts, can be disseminated repeatedly through the initiative's robust social media channels, e-newsletters, and patient materials. Million Hearts can also activate clinical partners and health advocates to equip clinicians with tools that address these issues.

Limitations

These findings should be interpreted in light of numerous issues of survey design and analysis. Without additional information about individuals who declined to complete the survey, characteristics of individuals who did and did not complete the survey cannot be compared. ConsumerStyles respondents self-reported all data used in these analyses and no information is available to validate their responses. Nonetheless, systematic or differential reporting biases are not expected to affect these results. In addition, information about whether any air quality alerts were issued in the areas where respondents live or about respondents' actual or potential air pollution exposures, including exposures to ozone or other specific pollutants that may be important determinants of air quality during the summer months, are unavailable. Consequently, the extent to which respondents are truly affected by poor air quality where they live remains unknown.

CONCLUSIONS

In this study, existing respiratory disease, but not heart disease, was associated with increased air quality awareness. In conjunction with the current understanding of the mechanisms by which air pollution exposures exacerbate existing disease among adults with asthma, COPD, and heart disease,[2,3,25] and affect respiratory and cardiovascular mortality globally,[26] these findings reveal opportunities to raise awareness about air quality alerts and behavior changes aimed at reducing air pollution exposure during periods of unhealthy air quality.

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Table 1

Demographic Characteristics, Survey Year, and Respiratory and Heart Disease Status of 2014–2016 SummerStyles Respondents

Respondent characteristics	n[a]	Weighted % (95% CI)[b]
Total	12,599	100
Demographic characteristics		
Age, years		
18–24	831	12.4 (11.6, 13.2)
25–34	1,530	17.6 (16.7, 18.4)
35–44	2,049	16.6 (15.8, 17.4)
45–54	2,817	18.1 (17.3, 18.8)
55–64	2,624	16.6 (15.9, 17.3)
65–74	1,918	13.2 (12.6, 13.9)
75–94	830	5.5 (5.1, 5.9)
Educational attainment		
Less than high school	869	12.3 (11.4, 13.1)
High school	3,730	29.6 (28.7, 30.6)
Some college	3,851	28.7 (27.8, 29.6)
Bachelor’s degree or higher	4,149	29.4 (28.5, 30.3)
Race/ethnicity		
White, non-Hispanic	9,396	65.6 (64.6, 66.7)
Black, non-Hispanic	1,232	11.6 (10.9, 12.3)
2+ races, non-Hispanic	254	1.3 (1.1, 1.4)
Other, non-Hispanic	386	6.4 (5.7, 7.1)
Hispanic	1,331	15.1 (14.3, 16)
Sex		
Female	6,606	51.8 (50.7, 52.8)
Male	5,993	48.2 (47.2, 49.3)
Smoking status		
Current smoker	1,745	14.5 (13.8, 15.3)
Former smoker	3,888	28.0 (27.1, 28.9)
Lifetime non-smoker	6,966	57.5 (56.5, 58.5)
Survey year		
2014	4,269	33.9 (32.9, 34.9)
2015	4,127	32.7 (31.8, 33.7)
2016	4,203	33.4 (32.4, 34.3)
Respiratory and heart diseases		
Asthma		
Yes	863	6.9 (6.4, 7.5)

Respondent characteristics	*n*[a]	Weighted % (95% CI)[b]
No	11,736	93.1 (92.5, 93.6)
Emphysema/COPD		
Yes	359	2.3 (2.1, 2.6)
No	12,240	97.7 (97.4, 97.9)
Heart disease		
Yes	503	3.4 (3.1, 3.8)
No	12,096	96.6 (96.2, 96.9)
Any of the above		
Yes	1,526	11.3 (10.6, 11.9)
No	11,073	88.7 (88.1, 89.4)

[a]Unweighted number of respondents.

[b]Unadjusted.

COPD, chronic obstructive pulmonary disease.

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Table 2

Numbers and Weighted Percentages Reporting Air Quality Awareness by Demographic Characteristics and Survey Year

	Aware of air quality alerts		Discussed with a health professional[a]		Avoided busy roads to reduce air pollution exposure					
					Always/usually		Sometimes/rarely		Never	
Respondent characteristics	*n*[b]	Weighted % (95% CI)[c]	*n*[b]	Weighted % (95% CI)[c]	*n*[b]	Weighted % (95% CI)[c]	*n*[b]	Weighted % (95% CI)[c]	*n*[b]	Weighted % (95% CI)[c]
Total	6,844	49.2 (48.1, 50.2)	364	3.0 (2.6, 3.3)	3,587	27.3 (26.4, 28.3)	3,686	30.0 (29.1, 31.0)	5,326	42.6 (41.6, 43.6)
Age, years										
18–24	289	34.8 (31.3, 38.4)	20	2.6 (1.4, 3.8)	162	20.6 (17.5, 23.6)	260	30.9 (27.5, 34.3)	409	48.6 (44.9, 52.3)
25–34	597	37.8 (35.1, 40.5)	24	1.8 (1.0, 2.6)	334	21.7 (19.3, 24.0)	545	36.2 (33.5, 38.9)	651	42.1 (39.3, 44.9)
35–44	970	44.9 (42.3, 47.4)	57	2.5 (1.7, 3.3)	514	25.7 (23.4, 28.0)	685	34.8 (32.3, 37.3)	850	39.4 (36.9, 41.9)
45–54	1,585	51.7 (49.5, 53.9)	69	2.5 (1.8, 3.2)	834	29.5 (27.5, 31.5)	860	29.7 (27.7, 31.7)	1,123	40.8 (38.6, 42.9)
55–64	1,653	59.4 (57.2, 61.7)	91	3.8 (2.9, 4.6)	860	31.7 (29.7, 33.7)	712	27.3 (25.3, 29.3)	1,052	41.0 (38.8, 43.1)
65–74	1,245	62.4 (59.9, 64.9)	72	4.4 (3.3, 5.6)	638	34.0 (31.6, 36.4)	458	22.8 (20.7, 24.9)	822	43.2 (40.7, 45.7)
75–94	505	59.6 (55.8, 63.4)	31	4.5 (2.6, 6.3)	245	29.2 (25.7, 32.6)	166	20.8 (17.7, 24.0)	419	50.0 (46.2, 53.8)
Educational attainment										
Less than high school	319	36.5 (32.9, 40.1)	45	5.0 (3.4, 6.6)	209	24.2 (21.0, 27.4)	227	27.9 (24.5, 31.3)	433	47.9 (44.1, 51.6)
High school	1,706	42.3 (40.5, 44.1)	78	2.1 (1.6, 2.6)	905	23.4 (21.9, 24.9)	945	26.1 (24.4, 27.8)	1,880	50.5 (48.6, 52.4)
Some college	2,071	49.4 (47.5, 51.3)	127	3.2 (2.6, 3.9)	1,161	29.8 (28.1, 31.5)	1,122	30.1 (28.3, 31.8)	1,568	40.1 (38.3, 42.0)
Bachelor’s degree or higher	2,748	61.2 (59.4, 63.0)	114	2.7 (2.1, 3.3)	1,312	30.2 (28.6, 31.8)	1,392	34.9 (33.2, 36.7)	1,445	34.9 (33.2, 36.6)
Race/ethnicity										
White, non-Hispanic	5,492	54.9 (53.7, 56.1)	204	2.1 (1.8, 2.5)	2,597	26.1 (25.1, 27.1)	2,680	28.5 (27.5, 29.6)	4,119	45.3 (44.2, 46.5)
Black, non-Hispanic	497	36.3 (33.2, 39.3)	78	6.1 (4.5, 7.6)	360	28.4 (25.5, 31.3)	358	29.7 (26.7, 32.8)	514	41.9 (38.7, 45.1)

Respondent characteristics	Aware of air quality alerts		Discussed with a health professional[a]		Avoided busy roads to reduce air pollution exposure					
					Always/usually		Sometimes/rarely		Never	
	n[b]	Weighted % (95% CI)[c]	*n*[b]	Weighted % (95% CI)[c]	*n*[b]	Weighted % (95% CI)[c]	*n*[b]	Weighted % (95% CI)[c]	*n*[b]	Weighted % (95% CI)[c]
2+ races, non-Hispanic	136	46.0 (38.8, 53.1)	13	4.5 (1.7, 7.3)	74	25.0 (18.9, 31.2)	72	30.0 (23.3, 36.8)	108	44.9 (37.7, 52.2)
Other, non-Hispanic	159	39.4 (34.1, 44.8)	17	4.0 (1.9, 6.1)	132	32.9 (27.8, 38.1)	145	37.6 (32.2, 42.9)	109	29.5 (24.5, 34.6)
Hispanic	560	38.6 (35.6, 41.6)	52	3.6 (2.5, 4.8)	424	29.5 (26.7, 32.3)	431	33.6 (30.7, 36.6)	476	36.8 (33.8, 39.8)
Sex										
Female	3,372	46.0 (44.6, 47.4)	214	3.4 (2.9, 4.0)	2,006	29.0 (27.7, 30.3)	1,867	29.0 (27.6, 30.3)	2,733	42.0 (40.6, 43.4)
Male	3,472	52.6 (51.1, 54.1)	150	2.5 (2.0, 2.9)	1,581	25.5 (24.2, 26.8)	1,819	31.2 (29.8, 32.6)	2,593	43.3 (41.8, 44.8)
Smoking status										
Current smoker	837	43.5 (40.7, 46.2)	58	3.9 (2.7, 5.0)	405	22.9 (20.5, 25.2)	496	30.5 (27.8, 33.1)	844	46.7 (43.9, 49.5)
Former smoker	2,218	52.3 (50.5, 54.2)	122	3.3 (2.6, 4.0)	1,135	28.0 (26.4, 29.6)	1,029	26.5 (24.8, 28.1)	1,724	45.5 (43.7, 47.3)
Lifetime non-smoker	3,789	49.1 (47.7, 50.5)	184	2.6 (2.1, 3.0)	2,047	28.1 (26.9, 29.4)	2,161	31.7 (30.4, 33.0)	2,758	40.2 (38.8, 41.6)
Survey year										
2014	2,307	47.9 (46.1, 49.7)	164	3.7 (3.1, 4.4)	1,082	25.1 (23.5, 26.6)	1,148	27.1 (25.4, 28.7)	2,039	47.9 (46.1, 49.7)
2015	2,220	49.2 (47.4, 51.0)	93	2.5 (1.9, 3.1)	1,189	27.9 (26.3, 29.5)	1,249	31.1 (29.4, 32.7)	1,689	41.0 (39.3, 42.8)
2016	2,317	50.4 (48.6, 52.3)	107	2.6 (2.0, 3.2)	1,316	29.1 (27.4, 30.7)	1,289	32.1 (30.4, 33.8)	1,598	38.8 (37.1, 40.6)

[a] Strategies to reduce air pollution exposure.

[b] Unweighted number of respondents.

[c] Unadjusted.

Table 3

Unadjusted Percentages of Air Quality Awareness and Associations With Asthma, Emphysema/COPD, and Heart Disease Status

	Selected respiratory and heart disease status				
	Yes		No		
Air quality awareness	***n*[a]**	**Weighted % (95% CI)[b]**	***n*[a]**	**Weighted % (95% CI)[b]**	**PR (95% CI)[b]**
Aware of air quality alerts					
Asthma	497	51.9 (47.9, 55.9)	6,347	49.0 (47.9, 50.0)	1.06 (0.98, 1.15)
Emphysema/COPD	223	60.2 (54.5, 66.0)	6,621	48.9 (47.9, 50.0)	1.23 (1.12, 1.36)
Heart disease	302	57.9 (52.9, 62.9)	6,542	48.9 (47.8, 49.9)	1.18 (1.08, 1.29)
Any of the above	905	55.0 (52.0, 58.0)	5,939	48.4 (47.3, 49.5)	1.14 (1.07, 1.20)
Discussed with a health professional strategies to reduce air pollution exposure					
Asthma	105	11.8 (9.3, 14.3)	259	2.3 (2.0, 2.6)	5.15 (3.98, 6.65)
Emphysema/COPD	34	11.4 (7.6, 15.3)	330	2.8 (2.4, 3.1)	4.15 (2.89, 5.95)
Heart disease	24	5.4 (2.8, 8.0)	340	2.9 (2.5, 3.2)	1.89 (1.15, 3.10)
Any of the above	132	9.1 (7.4, 10.8)	232	2.2 (1.8, 2.5)	4.16 (3.25, 5.32)
Avoided busy roads to reduce air pollution exposure					
Asthma					
Always/usually	287	30.5 (26.9, 34.0)	3,300	27.1 (26.1, 28.0)	1.12 (1.00, 1.27)
Sometimes/rarely	238	27.6 (24.0, 31.2)	3,448	30.2 (29.2, 31.2)	0.91 (0.80, 1.04)
Never	338	41.9 (37.9, 45.9)	4,988	42.7 (41.6, 43.7)	0.98 (0.89, 1.08)
Emphysema/COPD					
Always/usually	103	29.0 (23.8, 34.3)	3,484	27.3 (26.4, 28.2)	1.06 (0.88, 1.28)

	Selected respiratory and heart disease status				
	Yes		No		
Air quality awareness	n^a	Weighted % (95% CI)^b	n^a	Weighted % (95% CI)^b	PR (95% CI)^b
Sometimes/rarely	62	17.8 (13.3, 22.4)	3,624	30.3 (29.4, 31.3)	0.59 (0.45, 0.76)
Never	194	53.2 (47.4, 59.0)	5,132	42.4 (41.3, 43.4)	1.25 (1.12, 1.40)
Heart disease					
Always/usually	137	25.9 (21.6, 30.2)	3,450	27.4 (26.4, 28.3)	0.95 (0.80, 1.12)
Sometimes/rarely	112	23.1 (18.8, 27.4)	3,574	30.3 (29.3, 31.3)	0.76 (0.63, 0.92)
Never	254	51.0 (46.0, 56.0)	5,072	42.3 (41.3, 43.4)	1.21 (1.09, 1.33)
Any of the above					
Always/usually	466	29.1 (26.4, 31.7)	3,121	27.1 (26.1, 28.1)	1.07 (0.97, 1.18)
Sometimes/rarely	375	25.4 (22.8, 28.1)	3,311	30.6 (29.6, 31.7)	0.83 (0.74, 0.93)
Never	685	45.5 (42.6, 48.5)	4,641	42.3 (41.2, 43.3)	1.08 (1.00, 1.16)

[a] Unweighted number of respondents.

[b] Unadjusted.

COPD, chronic obstructive pulmonary disease; PR, prevalence ratio.

Table 4

Adjusted Prevalences of Air Quality Awareness and Associations With Asthma, Emphysema/COPD, and Heart Disease Status

	Selected respiratory and heart disease status		
Air quality awareness	**Yes, Prevalence (95% CI)[a]**	**No, Prevalence (95% CI)[a]**	**PR (95% CI)[a]**
Aware of air quality alerts			
Asthma	54.4 (50.6, 58.1)	48.8 (47.7, 49.9)	1.11 (1.04, 1.20)
Emphysema/COPD	53.6 (47.8, 59.3)	49.1 (48.0, 50.1)	1.09 (0.98, 1.22)
Heart disease	48.8 (43.9, 53.7)	49.2 (48.1, 50.2)	0.99 (0.90, 1.10)
Any of the above	53.1 (50.2, 56.0)	48.7 (47.6, 49.8)	1.09 (1.03, 1.16)
Discussed with a health professional strategies to reduce air pollution exposure			
Asthma	11.3 (9.1, 14.0)	2.3 (2.0, 2.7)	4.88 (3.74, 6.37)
Emphysema/COPD	9.2 (6.2, 13.3)	2.8 (2.4, 3.2)	3.31 (2.21, 4.95)
Heart disease	4.5 (2.7, 7.3)	2.9 (2.6, 3.3)	1.54 (0.93, 2.55)
Any of the above	8.4 (6.8, 10.2)	2.2 (1.9, 2.6)	3.79 (2.93, 4.89)
Avoided busy roads to reduce air pollution exposure			
Asthma			
Always/usually	30.7 (27.4, 34.2)	27.1 (26.1, 28.1)	1.13 (1.01, 1.27)
Sometimes/rarely	28.2 (24.7, 31.9)	30.2 (29.2, 31.2)	0.93 (0.82, 1.06)
Never	41.2 (37.4, 45.1)	42.7 (41.7, 43.8)	0.96 (0.87, 1.06)
Emphysema/COPD			
Always/usually	29.1 (24.0, 34.7)	27.3 (26.4, 28.2)	1.06 (0.88, 1.28)
Sometimes/rarely	22.8 (17.7, 28.9)	30.2 (29.2, 31.2)	0.76 (0.59, 0.97)
Never	48.1 (42.1, 54.2)	42.5 (41.5, 43.5)	1.13 (1.00, 1.29)
Heart disease			
Always/usually	23.9 (20.0, 28.1)	27.5 (26.6, 28.4)	0.87 (0.73, 1.03)
Sometimes/rarely	27.7 (23.1, 32.9)	30.1 (29.2, 31.1)	0.92 (0.77, 1.10)
Never	48.4 (43.4, 53.5)	42.4 (41.4, 43.5)	1.14 (1.03, 1.27)
Any of the above			
Always/usually	28.6 (26.1, 31.2)	27.2 (26.2, 28.2)	1.05 (0.95, 1.16)
Sometimes/rarely	27.8 (25.1, 30.6)	30.3 (29.3, 31.4)	0.92 (0.82, 1.02)
Never	43.7 (40.8, 46.6)	42.5 (41.4, 43.6)	1.03 (0.96, 1.10)

[a]Adjusted for age, educational attainment, race/ethnicity, sex, smoking status, and survey year.

COPD, chronic obstructive pulmonary disease; PR, prevalence ratio.