Enhancing Environmental Health Literacy about the Asthma- Air Pollution Connection at Childcare Centers in Asthma Prevalent Philadelphia Neighborhoods

Journal of Health Disparities Research and Practice

Volume 14 | Issue 3 Article 5

2021

Enhancing Environmental Health Literacy about the Asthma- Air Pollution Connection at Childcare Centers in Asthma Prevalent Philadelphia Neighborhoods

Thomas P. McKeon , *University of Pennsylvania*, mckeont@pennmedicine.upenn.edu
Frances S. Shofer , *University of Pennsylvania*, shofer@pennmedicine.upenn.edu
Marilyn V. Howarth , *University of Pennsylvania*, howarthmv@gmail.com

Enhancing Environmental Health Literacy about the Asthma- Air Pollution Connection at Childcare Centers in Asthma Prevalent Philadelphia Neighborhoods

Abstract

Objective: To determine environmental health literacy of childcare providers about outdoor air quality alert resources, the connection between air pollution and asthma and determine if childcare providers would use the resource to benefit children in their care. Methods: We designed a free outreach program about asthma prevalence, dangers of poor air quality, and air quality alert resources for staff at childcare centers in Philadelphia, Pennsylvania during summer and fall of 2015-2017. Pre-surveys were administered to evaluate baseline understanding. Post-surveys were administered at 4 weeks and returned within 4-12 weeks. Summary statistics were calculated, and pre/post knowledge compared using a paired t-test. Results: 258 staffers at 45 childcare centers attended the presentations. 214 completed both pre/post surveys. 74% reported never/rarely using air quality alerts before the program. Post-survey, 40% reported signing up for alerts. Post-survey there was an 8% mean increase in knowledge score (95% CI: 6.3-9.5%, Conclusions: This easily administered program using freely available information was useful to childcare providers and increased their environmental health literacy to benefit children in their care.

Keywords: Environmental Health Literacy; Air Pollution; Asthma; Community Engagement; Public Health

Objective: To determine environmental health literacy of childcare providers about outdoor air quality alert resources, the connection between air pollution and asthma and determine if childcare providers would use the resource to benefit children in their care. Methods: We designed a free outreach program about asthma prevalence, dangers of poor air quality, and air quality alert resources for staff at childcare centers in Philadelphia, Pennsylvania during summer and fall of 2015-2017. Pre-surveys were administered to evaluate baseline understanding. Post-surveys were administered at 4 weeks and returned within 4-12 weeks. Summary statistics were calculated, and pre/post knowledge compared using a paired t-test. Results: 258 staffers at 45 childcare centers attended the presentations. 214 completed both pre/post surveys. 74% reported never/rarely using air quality alerts before the program. Post-survey, 40% reported signing up for alerts. Post-survey there was an 8% mean increase in knowledge score (95% CI: 6.3-9.5%, pConclusions: This easily administered program using freely available information was useful to childcare providers and increased their environmental health literacy to benefit children in their care.

Keywords

Environmental Health Literacy; Air Pollution; Asthma; Community Engagement; Public Health

Cover Page Footnote

Acknowledgements Sean Greene, Julia Strapp, Erin Burke from the DVRPC for providing support in program material design and production. Lorna Rosenberg from the US EPA for providing guidance and support on the Air Flags Program. University of Pennsylvania graduate and undergraduate students for assisting in conducting presentations and transporting presentation supplies. Financial support: Supported by NIEHS Grant # 5-P30ES013508-11, the Center of Excellence in Environmental Toxicology P30-ES013508, and the PA Department of Health's SAP Vendor # 117579

Journal of Health Disparities Research and Practice
Volume 14, Issue 3, Fall 2021, pp. 73-98
School of Public Health
University of Nevada, Las Vegas

Enhancing Environmental Health Literacy about the Asthma- Air Pollution Connection at Childcare Centers in Asthma Prevalent Philadelphia Neighborhoods

Thomas P. McKeon, University of Pennsylvania
Frances S. Shofer, University of Pennsylvania
Marilyn V. Howarth, University of Pennsylvania
Corresponding Author: Marilyn V. Howarth, howarthmv@gmail.com

ABSTRACT

Objective: To determine environmental health literacy of childcare providers about outdoor air quality alert resources, the connection between air pollution and asthma and determine if childcare providers would use the resource to benefit children in their care.

Methods: We designed a free outreach program about asthma prevalence, dangers of poor air quality, and air quality alert resources for staff at childcare centers in Philadelphia, Pennsylvania during summer and fall of 2015-2017. Pre-surveys were administered to evaluate baseline understanding. Post-surveys were administered at 4 weeks and returned within 4-12 weeks. Summary statistics were calculated, and pre/post knowledge compared using a paired t-test.

Results: 258 staffers at 45 childcare centers attended the presentations. 214 completed both pre/post surveys. 74% reported never/rarely using air quality alerts before the program. Post-survey, 40% reported signing up for alerts. Post-survey there was an 8% mean increase in knowledge score (95% CI: 6.3-9.5%).

Conclusions: This easily administered program using freely available information was useful to childcare providers and increased their environmental health literacy to benefit children in their care.

Keywords: Environmental Health Literacy; Air Pollution; Asthma; Community Engagement; Public Health

INTRODUCTION

The Center of Excellence in Environmental Toxicology is a National Institute of Environmental Health Sciences (NIEHS) funded Environmental Health Science Core Center with a Community Engagement Core dedicated to improving environmental health in the Philadelphia region. Asthma is a significant health problem related in part to environmental factors. The work described here aims to mitigate the impact of air pollution on children with asthma.

Poor outdoor air quality and other environmental exposures can trigger asthma, a chronic lung disease that makes it harder for an individual to breathe (American Lung Association, 2020; Orellano et al., 2017). If not effectively managed, asthma can be a life-threatening disease, which can lead to permanent airway changes and reduced lung capacity (Asthma and Allergy Foundation of America, 2015). Asthma is the most common chronic condition among children, affecting 5.5 million children under 18 years of age (Data Resource Center for Child & Adolescent Health, 2020). Asthma is the third leading cause of hospitalization among children under 15 years, and in 2010, approximately 640,000 emergency room visits were due to asthma in those under 15 years (Lawal & Araujo, 2012).

The World Health Organization (WHO) estimates 4.2 million premature deaths globally are linked to outdoor air pollution. These deaths are mainly from heart disease, stroke, chronic obstructive pulmonary disease, lung cancer, and acute respiratory infections in children (World Health Organization, 2018). Significant evidence exists associating health risks with particulate matter of 2.5 microns in diameter ($PM_{2.5}$) or less and ozone (O_3) (Li et al., 2019). Fine particulates are capable of penetrating deep into the lung and being readily transferred to the blood, causing respiratory, cardiovascular, and cerebrovascular disease (Lawal & Araujo, 2012). There is no safe length of exposure to air pollution, both short and long-term exposure can result in exacerbations of asthma and respiratory infections, and reduced lung function in children and adults (World Health Organization, 2018). Epidemiological studies assessing exposure to ultra-fine particulates and childhood asthma have shown a positive association (Li et al., 2019; Lim et al., 2016). The American Thoracic Society in a recent published Workshop Report found that a causal relationship exits for long-term air pollution exposure and the onset of childhood asthma (Thurston et al., 2020). A study investigating acute associations between fine particulates/ ozone and asthma exacerbations found a positive association of acute asthma visits to a healthcare facility (Rosenquist et al., 2020). A study examining the prevalence of childhood asthmatic symptoms, comparing children living in regions with high and low ozone concentrations and without the confounding effects of other pollutants found that high ozone regions worsened childhood asthma (Sousa et al., 2009). According to the Centers for Disease Control and Prevention (CDC), the latest asthma data places the national asthma prevalence among adults at 7.7% and children at 7.5%. Pennsylvania ranks higher than the national average at 10% of its residents suffering from asthma (Centers for Disease Control and Prevention, 2020). Asthma rates in Philadelphia children vary by neighborhood but are 2-3 times higher than the Commonwealth of Pennsylvania (Bryant-Stephens et al., 2012).

Comprehensive multicomponent community-based interventions for childhood asthma have been shown to reduce asthma related emergency department visits, hospitalizations, and nights with asthma symptoms (Chan et al., 2021). These interventions often aim to enhance health literacy and provide resources to families. Environmental triggers that are most often considered are indoor allergens and irritants such as cockroach and dust mite allergen, cigarette smoke and cleaning chemicals (Janevic et al., 2016, Rapp et al., 2017). Schools have been included in community-based

interventions but often the setting is in elementary schools and the intervention has focused on the completion of an Asthma Action Plan and the facilitated referral to asthma subspecialists for poorly controlled asthma (Kercsmar et al., 2017, Findley et al., 2011). Providing training about asthma to childcare providers in a Head Start program has been found to increase their knowledge and skills in asthma care activities (Ruvalcaba et al., 2018) and when combined with other interventions has been shown to improve asthma control in a randomized control trial (Eakin et al., 2020). Neither of these studies however, mention air pollution as a focus of educational efforts for childcare providers, possibly missing an opportunity to reduce this important asthma trigger.

The Environmental Protection Agency (EPA) provides daily air quality information at www.airnow.gov, and through the Delaware Valley Regional Planning Commission's Air Quality Partnership, a regional air quality program, at www.airqualitypartnership.org. Anyone can sign up to receive free outdoor air quality alerts specific to their region from these websites. AirNow details air quality conditions by using the EPA's Air Quality Index (AQI), which is a color-coded index designed to communicate whether current air quality conditions are at healthy or unhealthy levels (see Supplemental Figure 1). The AQI has values ranging from 0 to 500 which correspond to a composite assessment of five major air pollutants regulated by the Clean Air Act: $PM_{2.5}$, ground-level ozone, carbon monoxide, sulfur dioxide, and nitrogen dioxide (US-Environmental Protection Agency, 2020a). Higher AQI values indicate a greater level of air pollution and therefore signify a greater health concern. Ozone and fine particulates are the two air pollutants with established regulatory standards under the National Ambient Air Quality Standards which currently pose the greatest risk to human health in the United States since they most commonly exceed standards in counties with high population density (US-Environmental Protection Agency, 2020b; Laumbach, 2010). Secondary reactions from sunlight, nitrogen oxides which frequently emanate from vehicular traffic, and volatile organic compounds (VOCs) create ozone, typically leading to higher ozone levels during the hot summer months. Fine particulates are present year-round and can result from industrial pollution, motor vehicle exhaust, and wildfires. In the Northeast region of the US, particulate pollution is particularly elevated during the heating season due to air emissions from coal fired power plants which are prevalent in the region.

For most people, AQI values at or below 100 are generally thought of as satisfactory. At levels higher than 100, air quality is unhealthy, especially for sensitive groups such as, children, elderly, people who work outside, and those with heart and lung diseases. From 2014 to 2017, there were 768 (52.6%) days, which fell into the moderate or unhealthy categories: 722 (94.0%) yellow days, 41 (5.3%) orange days and 5 (0.7%) red days in Philadelphia County (US-Environmental Protection Agency, 2020a). The annual number of orange and red days has remained between 9 and 16, with 2014 reporting 9 days; 2015 reporting 16 days; 2016 reporting 9 days; 2017 reporting 12 days. In 2015, the EPA lowered its ground-level ozone standards from 75 parts per billion to 70 parts per billion resulting in more days deemed high ozone (US-Environmental Protection Agency, 2020b). Philadelphia has never been in compliance with the primary 8-hour ozone standard, and just recently came into compliance with the particulate standard.

As of 2018, an estimated 2.2 million Americans work in the early childhood workforce, caring for nearly 15 million children under the age of six (Center for the Study of Child Care Employment, 2020). Staffers at childcare centers have the power to make decisions for the children in their care. These decisions include when a child should or should not play outside, or whether a child is having

an asthmatic emergency. With Philadelphia having high childhood asthma rates and high rates of air pollution, the environmental health literacy, fundamentally defined as the understanding of the ways environmental contaminants affect human health (Hoover, 2019; Gray, 2018; Finn & O'Fallon, 2017), of childcare providers around the air pollution-asthma connection seemed relevant to study and important to enhance if not present. Mobile phone technology has been shown to be an effective method of enhancing environmental health literacy (Dellinger et al., 2019).

METHODS

Study Design and Setting

After obtaining an Institutional Review Board (IRB) Exemption from the University of Pennsylvania we conducted a quasi-experimental study with a one group, pre and post-test design, to evaluate and enhance environmental health literacy of childcare staffers at the individual level about the asthma-air pollution connection in Philadelphia, Pennsylvania.

Engagement of Childcare Centers

An introductory letter addressed to the education director of each childcare center described how the University of Pennsylvania's Perelman School of Medicine, through its Center of Excellence in Environmental Toxicology was working in their community to try to reduce asthma prevalence. The letter highlighted that the university was offering this as a free community outreach program to childcare staff, and if funds were available, mentioned that lunch would be provided. The letter described the purpose, content and benefits of the program and asked if the outreach program administrators could come in and talk for a few minutes to show materials associated with the presentation and schedule a time to conduct the presentation to the staffers.

Education directors with a publicly posted name received a personalized letter in the mail. Childcare centers with no listed education director received a letter simply addressed to "Education Director." The letter notified the recipient that they would be receiving a call within a week or two to ask for an opportunity to meet with a representative from the University of Pennsylvania. After a successful contact and subsequent meeting, a date and time was scheduled to present to the staffers. After the outreach program, all childcare centers were contacted and invited to sign up for EPA's Air Quality Flag program. This program is a collaboration between participating organizations and the EPA to sustain continued active surveillance of daily air quality forecasts. Air Quality Flag program enrollment allowed for measuring outcomes at the childcare center-level and included designating an enrolled childcare center as a certified program, which required that they identify a staffer as an air flags coordinator.

Inclusion Criteria

Childcare centers which were publicly listed as an established business were eligible for this study and assumed to meet Pennsylvania's Department of Human Services' 55 PA. Chapter 3270, certificate of compliance as a facility in which seven or more children, 15 years or younger, unrelated to the operator receive childcare services (Pennsylvania's Department of Human Services, 2020). Study participants included childcare staffers over the age of 18 years and working in a childcare center within the city limits of Philadelphia. All childcare personnel are required to have at least 6 credit hours of training each year which require both written and spoken English to be in compliance with PA state law. We relied on this understanding to expect our participants to be able to read and speak English. A convenience sampling using a standard Google search identified Philadelphia

childcare centers by using the keywords, "daycare", "early learning center", or "childcare center." Considering that every ZIP code in Philadelphia has historically had an asthma hospitalization rate higher than Pennsylvania's, any childcare center with a listed address and phone number was eligible for contact. This was later confirmed using the publicly available 2015 PA Health Care Cost Containment Council Report on Hospital Discharges (Pennsylvania Health Care Cost Containment Council, 2015). All participants gave consent to be included in the study.

Materials and Data Collection

The research team designed a 15-slide PowerPoint presentation, titled; "How Does Poor Outdoor Air Quality Affect Your Community?" The 15-20-minute presentation used visuals and brief text to convey information about asthma and its triggers, sources of outdoor air pollution, and how and why to sign up for free air quality forecasts. It encouraged staffers to sign up for air quality alerts through the EPA. The presentation included information on current national and local childhood asthma statistics, asthma's social, health, and financial consequences, how to tell when the air is unhealthy, how to use and understand air alerts, which populations are vulnerable to air pollution, and how to talk about this topic with friends and parents of children. Although the air quality pollutants vary seasonally, this presentation is designed to enhance environmental health literacy on air pollutant sources and air alert resources that is intended to be used year-round. The researchers used funding support to purchase a projector, print supplies, offer lunch, and train graduate students to conduct presentations. Undergraduate students in academically based community service courses at the University of Pennsylvania who were interested in participating in this program were also trained to conduct presentations. Lunch was provided when possible, to enhance participation. About 20 graduate and undergraduate students assisted in conducting the presentations.

Pre/post surveys were designed to measure environmental health literacy on air quality (See supplemental materials for pre/post surveys). The surveys consisted of Likert – scale, "true/false", and multiple-choice questions totaling to 40-points about outdoor air quality, air quality alert sites, and asthma. The surveys were scored based on an answer key. Likert – scale questions with a higher level of understanding received full points with diminishing points for each lower-level response. "True/false" questions received points for correct responses and none for incorrect. Multiple-choice questions were awarded points for each correct choice, and none for incorrect choices. The survey was administered prior to the presentation and a second survey was administered four weeks later, to evaluate changes in staffers' knowledge and behaviors. Education directors returned the completed survey within 4-12 weeks after program administration. To maintain survey anonymity, while allowing for matching pre/post surveys to each respondent, a unique identifier was created by each respondent. Additionally, demographics including age, sex, ethnicity/race, parental status, smoking status, knowing someone with asthma status, and home ZIP code were collected.

The Air Quality Partnership, a public/private coalition dedicated to improving air quality in the Greater Philadelphia Region, administered by the Delaware Valley Regional Planning Commission (DVRPC) assisted in designing and printing two-fold brochures to supplement the outreach presentation. This brochure, provided to participants after the survey was completed, summarized content found in the PowerPoint presentation and provided clearly written information on how to access air alert resources and where to learn more (see Supplemental Figure 2**)**. The DVRPC also provided coloring books, AQI flags, and intellectual support during the program

implementation, and post program to assist in continued community engagement and ongoing environmental health education.

Analysis

Descriptive data are presented as frequencies for the survey responses, difference in pre/post-test scores, and short statements for the qualitative responses. A paired t-test was used to analyze the difference in the mean cumulative survey scores for the matched surveys using Stata statistical software (version 10, StataCorp, College Station, TX). Statistical significance was defined as a p-value < 0.05. ESRI's ArcGIS Desktop (version 10.5.1), a geospatial mapping software was used in preparation of mapping geographic data about the childcare centers that successfully received the outreach program. To test sensitivity, we repeated the paired t-test analysis by stratifying the participants by those who reported having asthma or knowing someone with asthma and by those that did not report having or knowing someone with asthma.

The well-established Area Deprivation Index (ADI), a measure of neighborhood disadvantage that includes factors of income, education, employment, and housing quality was used to compare the contextual characteristics of the ZIP codes in which the childcare centers are located (Kind et al., 2018; Mora et al., 2020). The ADI uses an ordinal ranking for Pennsylvania ZIP codes from low (1) to high (10). The ADI was used to compare the neighborhoods of childcare centers that participated in this study to those that declined.

RESULTS

In total, 100 letters were mailed out and 45 childcare centers participated in the air-quality outreach program across Philadelphia (see Supplemental Figure 3) during the summer and fall months (June to October/November) of 2015, 2016, and 2017. 258 staffers received the presentation and completed the pre-survey. 214 staffers completed the post-survey upon follow up. 194 pre and post surveys were successfully matched. The Area Deprivation Index (ADI) of participating and non-participating childcare centers were proportionally similar, with 80% located in areas with high ADI (> 7), and 20% within areas with low ADI (< 3). Most staffers were female (88.1%), African American or black (68.0%), age equally distributed between 18-29 and 30-40 years (41.7%), and 47.4% reported having a college degree or beyond (Table 1). Additionally, 61.3% of staffers were parents, 15.5% were smokers and 67.5% reported suffering from asthma or knowing someone who was diagnosed as being asthmatic. 23.7% of the staffers did not report their home ZIP code or reported living outside the city of Philadelphia. Most of the staffers reported living in West Philadelphia and South Philadelphia (see Supplemental Figure 4). Before the outreach program, 73.7% of the participants reported never receiving air quality alerts. Only 7.2% reported often or always receiving air quality alerts before receiving this program.

Table 1. Participant demographics of 194 matched pre and post surveys

Characteristic		N	Frequency
Education	High School	25	12.9%
	Some College	71	36.6%
	College Degree	44	22.7%
	Beyond College	48	24.7%
	Not Reported	6	3.1%
Age	18-29	81	41.8%
	30-50	81	41.8%
	51 and older	29	14.9%
	Not Reported	3	1.5%
Race	African American/ Black	132	68.0%
	White	25	12.9%
	Multi-racial	11	5.7%
	Other	18	9.3%
	Not Reported	8	4.1%
Sex	Female	171	88.1%
	Male	6	3.1%
	Not Reported	17	8.8%
Parental Status	Parent	119	61.3%
	Non-Parent	73	37.6%
	Not Reported	2	1.1%
Smoker	Yes	30	15.4%
	No	162	83.5%
	Not Reported	2	1.1%
Do you or anyone you know have asthma?	Yes	131	67.5%
	No	61	31.4%
	Not Reported	2	1.1%

After the outreach presentation, 40.7% of the staffers reported signing up for free air quality alerts either by e-mail or phone text messages (Table 2). At post survey follow-up, 38.1% of the respondents reported receiving air quality alerts often or always, whereas 33.0% reported never receiving air quality alerts during this same follow up timeframe. 85.5% found the presentation easy or very easy to understand. After this community intervention, over half of the staffers (52.0%) reported changing how they cared for children, based on air quality forecast. There was a 3.2-point mean increase in knowledge score post outreach program (95% CI 2.5-3.8, $p<.0001$). This represented a statistically significant increase in knowledge, with 71.1% scoring better, 6.7% scoring no change in knowledge, and 22.2% scoring a decrease in knowledge (Figure 1). Post outreach program, 51% of the childcare centers signed up for EPA's Air Flags Program. For the sensitivity test, there was a 2.7- point mean increase in knowledge score for those reporting having or knowing someone with asthma (95% CI 1.9-3.5, $p<.0001$). and a 3.9 point-mean increase for those that do not have or know someone with asthma (95% CI 2.9-5.1, $p<.0001$).

Table 2. Participant responses, changes in knowledge and behavior

Characteristic	N	Frequency
Received the Outreach Presentation		
Completed Pre-Survey	258	100%
Completed Post-Survey	214	82.9%
Matched Pre-Post Surveys	194	90.7%
	133*	
	61**	
Responses of Matched Pre-Post Surveys N= 194		
Signed up for air quality alerts	79	40.7%
	37*	
	42**	
Increase in knowledge score	138	71.1%
	89*	
	49**	
No change in knowledge score	13	6.7%
	9*	
	4**	
Decrease in knowledge score	43	22.2%
	33*	
	10**	
Found the presentation easy or very easy to understand	165	85.0%
	113*	
	52**	
Reported changing activities based on air quality after outreach program	105	52.0%
	82*	
	23**	
Prior to outreach program never receiving air quality alerts	143	73.7%
	90*	
	53**	
Prior to outreach program often/always receiving air quality alerts	14	7.2%
	10*	
	4**	
4 weeks post outreach program never receiving air quality alerts	64	33.0%
	26*	
	38**	
4 weeks post outreach program often/always receiving air quality alerts	74	38.1%
	41*	
	33**	

* Those that answered yes to: "Do you or anyone close to you have asthma?"

** Those that answered no to: "Do you or anyone close to you have asthma?"

Figure 1: Plot of mean difference in knowledge scores.

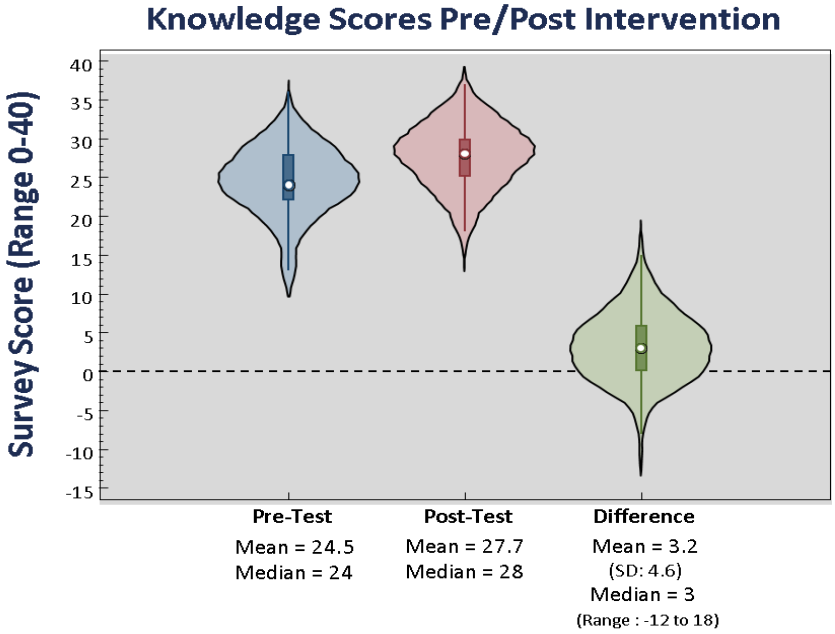


Figure1. Knowledge scores were calculated by adding points for all correct answers. Pre-test refers to the knowledge score achieved before the intervention and Post-test refers to the knowledge score four weeks after the intervention.

Open-ended responses were predominately positive for the questions: "Was the information about air quality that we gave you, useful to you? If yes, how did you use it? If no, why not?", "Have you changed your activities with the children you supervise based on air quality?" Most participants found the outreach program helpful and utilized the resources provided to manage activities with the children in their care (see Table 3 and Table 4 for quotes from several staffers)**.** For the question: "Did you sign up for air quality alerts? Why or why not?", many staffers signed up, and the most common reason for not doing so was not remembering to sign up after receiving the outreach program.

Table 3. Representative Responses to "Was the information about air quality that we gave you useful to you?"

"I check my app every morning. I have several students in my class who are asthmatic. This helps me to know the air quality outside."
"Because I wasn't aware of this issue previously."
"Before heading out to work. I would go to AirNow.gov to check if the weather outside is safe."
"Found out things I didn't know."
"I have asthma that has progressively gotten worse since moving to the city. This discussion explained why."
"I check to make sure children are able to go outside."
"I check AQI frequently on my phone."
"To know how many toxins are in the air."
"I found it interesting plus the resources were helpful for guiding our time outside as well as to share with the parents."
"I learned where to check for air quality for the day."
"I know how to check the air quality report. I understand that green is good and orange/red means poor air quality which can affect breathing abilities."
"Is important know that information for our health."
"I use it to see how the air is every day. If the air is okay for kids to play outside."
"By being more aware of the effects that air quality has on children."

Table 4. **Representative Responses to "**Have you changed your activities with the children you supervise based on air quality?"

"Yes. We make sure asthma medicine is given on time when we discuss the weather."	"No. They have the information for kids."
"Yes, to keep them healthy."	
"Yes, don't want my child to be in the hospital from asthma flares."	"No, because we were already checking for alerts and planning accordingly."
"Yes, I have a group discussion."	"No, my daycare always checks."
"Yes, being aware of air quality before going on walks."	
"Yes, we follow air quality guidelines."	"No, was not necessary."
"Yes, many have asthma, so it was very helpful."	
"Yes, I will check AQI whenever I doubt it."	"No, the school did not change the state mandated procedures."
"Yes, to adjust window heights according to weather conditions & children's needs."	

DISCUSSION

This easily administered outreach program utilizing a free nationally available air pollution resource available on mobile phones was shown to enhance environmental health literacy around the air pollution-asthma connection. This program was used by childcare staffers for the benefit of the children they care for. The childcare setting has been used to engage parents around asthma prevention and treatment. When childcare providers have been the target of intervention programs, air pollution has not been the focus of the educational efforts (Kercsmar et al., 2017, Findley et al., 2011). Recognizing the important potential role that childcare providers can play in the prevention of asthma exacerbation led this research team to develop a free program that can easily provide training about air pollution on its own or be incorporated as an adjunct into other asthma training that may be available. This program is the first to evaluate baseline knowledge and awareness of adult childcare staffers about poor outdoor air quality, illnesses associated with it and use of free air quality alert systems such as that found at EPA's www.airnow.gov.

Although there are many triggers for asthma exacerbations, air pollution has been shown to be an important contributor (Li et al., 2019, Lim et al., 2016). Urban areas like Philadelphia have higher levels of air pollution and the EPA's free and publicly available air alert system provides easily accessible air quality forecasts at the regional level for anyone with a mobile phone to use. Knowing when poor outdoor air quality days occur empowers people who care for populations sensitive to air pollution, such as children, the elderly, people with heart and lung diseases, and people who work outside to act on their behalf such as avoiding outdoor play or unnecessary travel on those days.

It has been shown that research benefits from incorporating community participation (Dilworth et al., 2009). An outreach program which is receptive to engaging with community partners and incorporates public and private resources, to the knowledge of the authors of this study, has not been done around air quality at childcare centers. Opportunities to reinforce the information shared in an outreach program at community events, in addition to childcare presentations may improve the outcomes of the program, improve researcher-community relations, and encourage natural growth of topic literacy.

Although most of the childcare staffers reported at least some college education, many of the staffers from the participating childcare centers had limited knowledge about free air quality alert resources. Before receiving this free outreach program, the majority of the staffers reported never checking outdoor air pollution despite most having asthma themselves or knowing someone with asthma. General lack of familiarity with these publicly available resources, highlighted the need for an outreach program. As a result of this program, a significant portion of the staffers signed up to receive air alerts from www.airnow.gov or www.airqualitypartnership.org. The increase in reported sign-up was significant, considering that very few reported receiving air alerts often/always before this program. Despite the minimal improvement of the knowledge scores, the increased use of air quality alerts suggests that the initiative was meaningful in practical significance. Some participants stated reasons for not signing up had to do with simply forgetting or not having the chance to do so yet. Reinforcing the importance of this information, with supportive follow up reminders could further improve these results. Limited access to smartphones or the internet may contribute to not being able to adopt air quality alert resources in some

participants. Another reason for not signing up was that they were receiving AQI information on a weather app.

Positive changes in behavior were reported, with most of the staffers stating they changed their day's activity with the children in their care, based on the air quality forecast. The increased use of resources to benefit the children in their care sheds light on the deficiencies in access to and experience with freely available resources by some segments of the public. Although some staffers did not change their activities based on air quality, the adoption of the EPA air quality flag program in 51% of the childcare settings may provide a future reminder to consider doing so. Since the air flags coordinator's role is to check the air quality forecast daily, and post a flag with the corresponding AQI color, their engagement with the program would be reinforced daily. The presence of the flag in the childcare center would also be expected to reinforce the air pollution-asthma connection for staffers. The flag may prompt questions by parents leading them to become engaged as well. Next steps in the research process would be to evaluate the enhanced awareness and positive behavior change of staffers long-term in response to the EPA Air Flags and to explore the awareness and impact on family members.

Although our study did not evaluate the baseline opinion or level of trust of childcare providers about the research team, we did experience positive feedback in several ways. One of the childcare chains that participated in the study, invited the researchers to a regional retreat for education directors to talk about this outreach program. This added visibility to the program, connected the researchers to additional locations for air quality outreach and other environmental health outreach programs. Other opportunities to attend community events also became available through childcare center connections providing the opportunity to expand the outreach about air quality and the air pollution-asthma connection to the community at large.

Community groups, agencies and government programs often operate in a siloed fashion. This program facilitated connections between public and private entities with a shared mission; to improve environmental health literacy and engagement around the air pollution-asthma connection. Collaborating with the EPA to encourage childcare centers to sign up for EPA's Air Flags program proved to be successful. More than half of the childcare centers enrolled in the program. The childcare center-EPA connection through this program is expected to facilitate the dissemination of new health information that may be developed. Collaborating with the Air Quality Partnership of the DVRPC provided financial support for materials and printing for this research and represents a model for ongoing collaboration around a shared mission. Through the Air Quality Partnership, the DVRPC recognizes the implications to health of their transportation management recommendations and as part of their mission engages in programs that reduce the impacts of air pollution by mobile sources. Engaging them in this case provided an opportunity for discussion among regional transportation planners and researchers. Several of the transportation planning groups adapted the program for their own use and distributed the materials produced at community events. The research team found the collaboration to be successful, allowing for ongoing discussion among collaborators to advance their agendas for the public good.

Studies evaluating trust of the healthcare system in Black communities, have reported that distrust of healthcare professionals exists in many of these communities (Omenka et al., 2020; Kennedy et al., 2007). Given that the majority of our study participants are Black, this distrust may extend to the researchers in this program since we are from a well-known healthcare system.

Evidence of enhanced trust in and social cohesion between community partners and researchers can be seen in the childcare directors' willingness to leverage their resources from within the childcare community to allow for opportunities to reinforce the information shared in this outreach program. We believe that enhanced trust was established by childcare providers who invited researchers to participate and share supplemental materials with the public at community events hosted by them.

The study was implemented over three years. Obstacles to expeditious implementation included funding for staff time and materials, and difficulty coordinating presentation schedules and transportation.

Our study does come with limitations. We did not evaluate whether enhanced environmental health literacy around the air pollution-asthma connection from this program would enhance the utilization of AQI information received from other sources (i.e. apps, news). Although the AQI data is not granular enough to differentiate local air pollution conditions between childcare centers which participated and those that did not, this would enhance understanding and engagement of the communities in future efforts when such information becomes available. Convenience sampling and scheduling constraints precluded obtaining a randomized sample. Although we reached out to 100 childcare centers across the city, those which were closer in proximity were easier to coordinate and schedule a presentation. This may have led to a selection bias for childcare centers which were more available and easier to schedule. Staff turnover and shift changes made it difficult to follow up with the same cohort for the post-survey. Individuals with potentially different levels of presentation quality conducted the presentations which may have led to a response bias. The presentations were conducted during work hours and some staff may have felt hurried to complete surveys due to work constraints. Although we provided the second survey four weeks after the first presentation, many childcare centers were not able to rapidly return the post survey and follow-up took up to 12 weeks. Although education directors were asked to provide the post surveys at 4 weeks, we have no way of determining when individual post surveys were completed, since education directors generally returned post surveys all at the same time.

In summary, this study of Philadelphia childcare providers found low baseline environmental health literacy around the air pollution-asthma connection and low utilization of freely available public resources on air quality. Although the childcare setting had previously been the site of asthma education for parents and childcare providers, air pollution and its role as an asthma trigger was not the focus of prior study. Through a collaboration with the Air Quality Partnership of the DVRPC and the US-EPA, researchers at the Community Engagement Core of the Center of Excellence in Environmental Toxicology designed a brief presentation to enhance environmental health literacy of childcare providers that prompted positive action to benefit children in their care. The improved knowledge and actions were found to be sustained at 4 week follow up and have the potential for long-term reinforcement through the EPA's Air Flag Program. The next step for this research is to test the long-term retention and benefits of ongoing reinforcement of the key messages using the EPA Air Flag program. This model community engagement program demonstrates the benefit of collaboration among public, private, and academic groups with shared missions. The program leveraged the publicly available AQI on mobile phones and provided 45 childcare centers with connections to academic and government

resources that were previously under-utilized. This collaborative model may prove useful for community engagement around other topics and with other audiences.

ACKNOWLEDGEMENTS

Sean Greene, Julia Strapp, Erin Burke from the DVRPC for providing support in program material design and production. Lorna Rosenberg from the US-EPA for providing guidance and support on the Air Flags Program. University of Pennsylvania graduate and undergraduate students for assisting in conducting presentations and transporting presentation supplies.

Financial support

Supported by NIEHS Grant # 5-P30ES013508-11, the Center of Excellence in Environmental Toxicology P30-ES013508, and the PA Department of Health's SAP Vendor # 117579

REFERENCES

American Lung Association. (2020). What Is Asthma? Retrieved April 17, 2021, from https://www.lung.org/lung-health-diseases/lung-disease-lookup/asthma

Asthma and Allergy Foundation of America. (2015). Air Pollution. Retrieved April 16, 2021, from https://www.aafa.org/air-pollution-smog-asthma/

Bryant-Stephens, T., West, C., Dirl, C., Banks, T., Briggs, V., & Rosenthal, M. (2012). Asthma Prevalence in Philadelphia: Description of Two Community-Based Methodologies to Assess Asthma Prevalence in an Inner-City Population. *Journal of Asthma*, 49(6), 581-585. doi:10.3109/02770903.2012.690476

Chan M, Gray M, Burns C, Owens L, Woolfenden S, Lingam R, Jaffe A, Homaira N. (2021). Community-based interventions for childhood asthma using comprehensive approaches: A systematic review and meta-analysis. *Allergy, Asthma & Clinical Immunology, 17*(1). doi:10.1186/s13223-021-00522-9

Centers for Disease Control and Prevention. (2020). Most Recent Asthma State Data. Retrieved April 16, 2021, from https://www.cdc.gov/asthma/most_recent_data_states.htm

Center for the Study of Child Care Employment. (2020, April 15). The Early Childhood Workforce Index 2018. Retrieved April 16, 2021, from https://cscce.berkeley.edu/early-childhood-workforce-2018-index/ Data Resource Center for Child & Adolescent Health. (2020). National Survey of Children's Health. Retrieved April 16, 2021, from https://www.childhealthdata.org/browse/survey

Dellinger, M.J., Lyons, M, Clark, R, Olson, J, Pingatore, N, Ripley, M. (2019) Culturally adapted mobile technology improves environmental health literacy in Laurentian, Great Lakes Native Americans (Anishinaabeg). *Journal of Great Lakes Research*,45 (5): 969-975. https://doi.org/10.1016/j.jglr.2019.07.003.

Dilworth, C., O'Fallon, L., & Gray, K. (2009). Community Engagement Benefits Environmental Health Research. *Epidemiology*, 20. doi:10.1097/01.ede.0000362315.07326.22

Eakin, M. N., Zaeh, S., Eckmann, T., Ruvalcaba, E., Rand, C. S., Hilliard, M. E., & Riekert, K. A. (2020). Effectiveness of A home- and SCHOOL-BASED Asthma educational program for head START children with asthma. *JAMA Pediatrics, 174*(12), 1191. doi:10.1001/jamapediatrics.2020.3375

Findley S., Rosenthal M., Bryant-Stephens T., Damitz M., Lara M., Mansfield C., Matiz A., Nourani V., Peretz P., Persky V.W., Valencia G.R., Uyeda K., Viswanathan M. (2011). Community-Based care coordination. *Health Promotion Practice, 12*(6_suppl_1). doi:10.1177/1524839911404231

Finn, S., & O'Fallon, L. (2017). The Emergence of Environmental Health Literacy-From Its Roots to Its Future Potential. *Environmental health perspectives*, *125*(4), 495–501. https://doi.org/10.1289/ehp.1409337

Gray, K. (2018). From content knowledge to community change: A review of representations of environmental health literacy. International Journal of Environmental Research and Public Health, 15(3), 466. doi:10.3390/ijerph15030466

Hoover A.G. (2019) Defining Environmental Health Literacy. In: Finn S., O'Fallon L. (eds) Environmental Health Literacy. Springer, Cham. https://doi.org/10.1007/978-3-319-94108-0_1

Janevic, M. R., Stoll, S., Wilkin, M., Song, P. X., Baptist, A., Lara, M., . . . Malveaux, F. J. (2016). Pediatric asthma care coordination in underserved Communities: A QUASIEXPERIMENTAL STUDY. *American Journal of Public Health*, 106(11), 2012-2018. doi:10.2105/ajph.2016.303373

Kennedy B.R., Mathis C.C., Woods A.K. (2007). African Americans and Their Distrust of the Health Care System: Healthcare for Diverse Populations. *J. Cult. Divers.* 14:56–60.

Kercsmar, C. M., Beck, A. F., Sauers-Ford, H., Simmons, J., Wiener, B., Crosby, L., . . . Mansour, M. (2017). Association of an ASTHMA Improvement collaborative with health Care utilization. In MEDICAID-INSURED pediatric patients in an urban community. JAMA Pediatrics, 171(11), 1072. doi:10.1001/jamapediatrics.2017.2600

Kind, A. J., & Buckingham, W. R. (2018). Making neighborhood-disadvantage metrics accessible — the neighborhood atlas. *New England Journal of Medicine, 378*(26), 2456-2458. doi:10.1056/nejmp1802313Lawal, A. O., & Araujo, J. A. (2012). Particulate Matter and Cardiovascular Health Effects. INTECH Open Access Publisher. doi:10.5772/38706

Laumbach, R. J. (2010). Outdoor air pollutants and patient health. American family physician, 81(2), 175–180.

Li, Q., Yi, Q., Tang, L., Luo, S., Tang, Y., Zhang, G., & Luo, Z. (2019). Influence of Ultrafine Particles Exposure on Asthma Exacerbation in Children: A Meta-Analysis. Current Drug Targets, 20(4), 412-420. doi:10.2174/1389450119666180829114252

Lim, H., Kwon, H., Lim, J., Choi, J. H., Ha, M., Hwang, S., & Choi, W. (2016). Short-term Effect of Fine Particulate Matter on Children's Hospital Admissions and Emergency Department Visits for Asthma: A Systematic Review and Meta-analysis. Journal of Preventive Medicine and Public Health, 49(4), 205-219. doi:10.3961/jpmph.16.037

Mora, J., Krepline, A. N., Aldakkak, M., Christians, K. K., George, B., Hall, W. A., . . . Tsai, S. (2020). Adjuvant therapy rates and overall survival in patients with localized pancreatic cancer from high area deprivation index neighborhoods. *The American Journal of Surgery*. doi:10.1016/j.amjsurg.2020.12.001

Omenka, O. I., Watson, D. P., & Hendrie, H. C. (2020). Understanding the healthcare experiences and needs of African immigrants in the United States: a scoping review. BMC public health, 20(1), 27. https://doi.org/10.1186/s12889-019-8127-9

Orellano, P., Quaranta, N., Reynoso, J., Balbi, B., & Vasquez, J. (2017). Effect of outdoor air pollution on asthma exacerbations in children and adults: Systematic review and multilevel meta-analysis. *PLOS ONE, 12*(3). doi:10.1371/journal.pone.0174050

Pennsylvania's Department of Human Services. (2020, December 19). CHAPTER 3270. CHILD CARE CENTERS. Retrieved April 15, 2021, from https://www.pacodeandbulletin.gov/Display/pacode?file=%2Fsecure%2Fpacode%2Fdata%2F055%2Fchapter3270%2Fchap3270toc.html

Pennsylvania Health Care Cost Containment Council. (n.d.). Public Reports. Retrieved January 07, 2021, from https://www.phc4.org/reports/

Rapp, K. I., Jack, L., Wilson, C., Hayes, S. C., Post, R., McKnight, E., & Malveaux, F. (2017). Improving asthma-related outcomes among Children participating in THE Head-off Environmental asthma in Louisiana (HEAL), Phase II STUDY. *Health Promotion Practice, 19*(2), 233-239. doi:10.1177/1524839917740126

Rosenquist, N. A., Metcalf, W. J., Ryu, S. Y., Rutledge, A., Coppes, M. J., Grzymski, J. J., . . . Darrow, L. A. (2020). Acute associations between PM2.5 and ozone concentrations and asthma exacerbations among patients with and without allergic comorbidities. *Journal of Exposure Science & Environmental Epidemiology, 30*(5), 795-804. doi:10.1038/s41370-020-0213-7

Ruvalcaba, E., Chung, S., Rand, C., Riekert, K. A., & Eakin, M. (2018). Evaluating the implementation of a multicomponent asthma education program for Head Start staff. *Journal of Asthma, 56*(2), 218-226. doi:10.1080/02770903.2018.1443467

Sousa, S. I., Alvim-Ferraz, M. C., Martins, F. G., & Pereira, M. C. (2009). Ozone exposure and its influence on the worsening of childhood asthma. Allergy, 64(7), 1046-1055. doi:10.1111/j.1398-9995.2009.01946.x

Thurston, G. D., Balmes, J. R., Garcia, E., Gilliland, F. D., Rice, M. B., Schikowski, T., . . . White, C. W. (2020). Outdoor air pollution and new-onset airway disease. An Official American Thoracic Society Workshop Report. *Annals of the American Thoracic Society, 17*(4), 387-398. doi:10.1513/annalsats.202001-046st

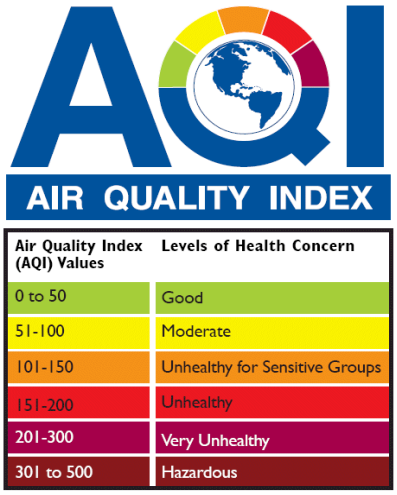
US-Environmental Protection Agency. (2020, November 17). Air Data: Air Quality Data Collected at Outdoor Monitors Across the US. Retrieved April 16, 2021, from https://www.epa.gov/outdoor-air-quality-data

US-Environmental Protection Agency. (2020, July 13). 2015 Revision to 2008 Ozone National Ambient Air Quality Standards (NAAQS) Related Documents. Retrieved April 16, 2021, from https://www.epa.gov/ground-level-ozone-pollution/2015-revision-2008-ozone-national-ambient-air-quality-standards-naaqsWorld Health Organization. (2018). Ambient air pollution. Retrieved April 16, 2021, from http://www.who.int/airpollution/ambient/health-impacts/en/

Supplemental Materials

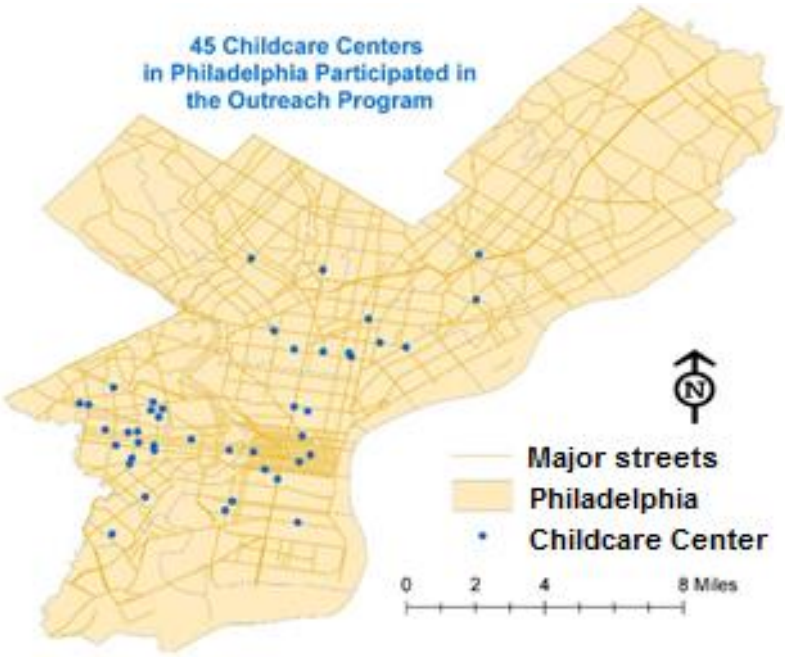
- **Supplemental Figure 1:** AQI used by AirNow
- **Supplemental Figure 2:** Two-fold brochure used in this study's presentations
- **Supplemental Figure 3:** Distribution of Participating Childcare Centers
- **Supplemental Figure 4:** Home ZIP codes of childcare center staffers
- **Supplemental Document 1:** Pre and Post survey

Supplemental Figure 1: Air Quality Index

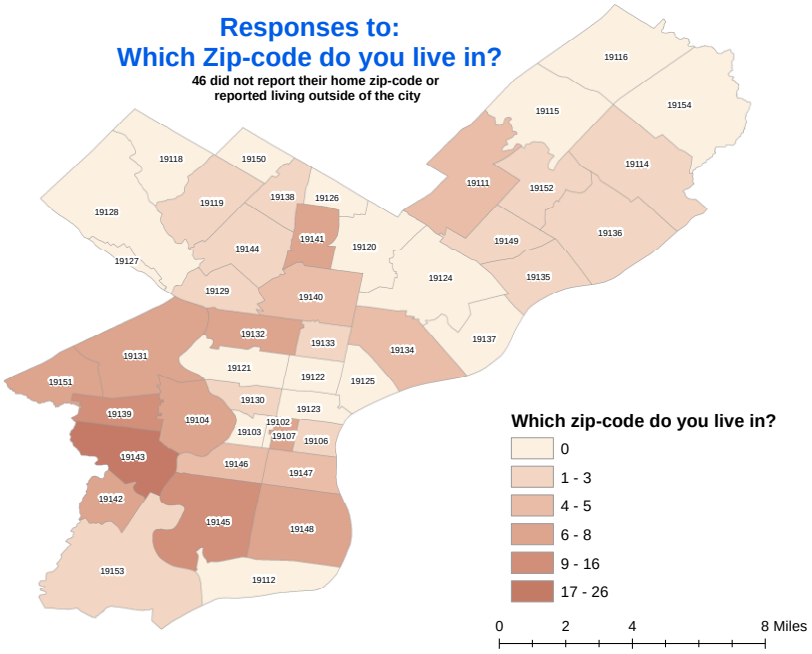


Supplemental Figure 2: Two-fold brochure used in presentations

Supplemental Figure 3: Geographic distribution of the 45 childcare centers which participated in this study



Supplemental Figure 4. Home ZIP codes of childcare center staffers



Supplemental Document 1: Pre and post Survey

Perelman School of Medicine University of Pennsylvania | Center of Excellence in Environmental Toxicology | dvrpc Delaware Valley Regional Planning Commission | AirNow

www.airnow.gov

www.airqualitypartnership.org

Outdoor air quality can be important to health. There is a high rate of asthma in your community and we would like to offer some help. We are asking that you complete this survey to help us learn what you think about air quality. We will ask you some more questions in a couple of months. Participation in this study is voluntary; we are not collecting your name so the information you give us cannot be linked back to you by name. We will ask a couple of questions so that we can match up the first and second surveys. Thank you!

I give my consent to participate in this study (*please check one*) ☐ No ☐ Yes

Unique Identifier Questions:

1. What street did you grow up on? _____
2. What is your mother's maiden name? _____
3. What is the 'day' part of your birthday? [redacted]/_____/[redacted]
   Month Day Year

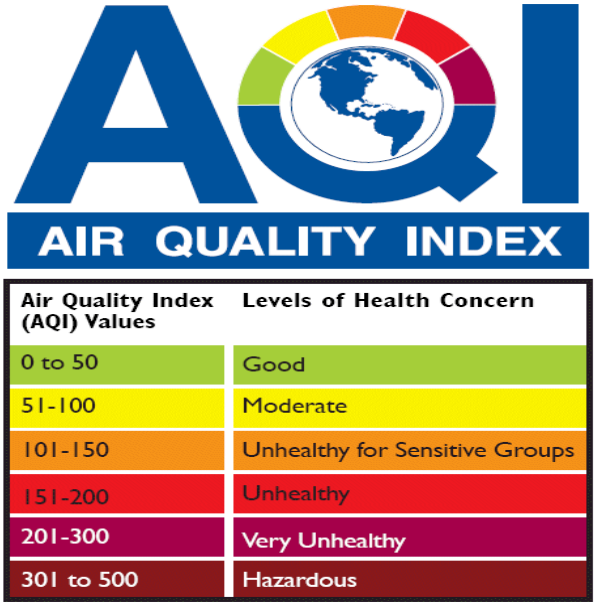
Demographic Information:

4. How old are you? ☐ 18-29 ☐ 30-50 ☐ 51 and older
5. Sex: ☐ Male ☐ Female
6. Are you Hispanic or Latino? ☐ No ☐ Yes ☐ Don't Know
7. What is your racial identification? (Please check ALL that apply)
   - ☐ African American, Black ☐ Pacific Islander
   - ☐ White, Caucasian ☐ Asian, Asian-American
   - ☐ Native American, American Indian, Alaska Native
   - ☐ More than one race/ethnicity (SPECIFY: _____)
   - ☐ Other (SPECIFY: _____) or
8. Are you a parent? ☐ No ☐ Yes
9. Do you currently smoke? ☐ No ☐ Yes
10. Do you anyone close to you have asthma? ☐ No ☐ Yes

Below you will find a list of questions about outdoor air quality, air quality alert sites, and asthma. Please answer all questions. Check the best answer for each.	
12. Do you use an air quality alert site such as www.airnow.gov?	☐ Never ☐ Rarely ☐ Often ☐ Always 4
13. Do friends, family and coworkers talk about outdoor air quality with you?	☐ Never ☐ Rarely ☐ Often ☐ Always 4
14. Before going outside, do you think about what the air quality is like?	☐ Never ☐ Rarely ☐ Often ☐ Always 4
15. Check all the sources of poor outdoor air quality from these options:	☐ Rain ☐ Clouds ☐ Bicycles ☐ Pollen ☐ Coal-fired Power Plants ☐ Trees ☐ Cars ☐ Smoking ☐ Lakes ☐ Parks 10
16. How much of a risk is air pollution to you and the children under your care?	☐ Don't Know ☐ Little Risk ☐ Some Risk ☐ Big Risk 4
17. How interested are you in learning more about air quality and its effect on health?	☐ Not Interested ☐ Some Interest ☐ Interested ☐ Very Interested 4
18. The Air Quality Index (AQI) color orange means unhealthy for groups sensitive to air pollution. Which of the following are sensitive groups to air pollution? (Check all that apply)	☐ Elderly ☐ Children ☐ Young Adults ☐ People with lung problems ☐ Teachers ☐ Factory Workers ☐ Asthmatics ☐ People who use crutches 8
19. Do you find the Air Quality Index easy to understand?	☐ No ☐ Yes 2

11. Which zip code do you live in? _____

Please Turn Over



Perelman School of Medicine University of Pennsylvania | Center of Excellence in Environmental Toxicology | dvrpc Delaware Valley Regional Planning Commission | AirNow

www.airnow.gov

www.airqualitypartnership.org

Outdoor air quality can be important to health. We hope you have found our information useful. There is a high rate of asthma in your community and we are happy to have had the opportunity to offer this information. We are asking that you complete this follow up survey to help us learn how useful our community air quality program was to you. Participation in this study is voluntary; we are not collecting your name so the information you give us cannot be linked back to you by name. We will ask the same few questions so that we can match up the first and second surveys. Thank you!

I give my consent to participate in this study (*please check one*) ☐ No ☐ Yes

Unique Identifier Questions:

1. What is your favorite animal? _____
2. What are the last two digits of your cell phone number? _____

3. What is the 'day' part of your birthday? [redacted]/_____ / _[redacted]
   Month Day Year

---

4. Did you attend the air quality talk?

   ☐ No ☐ Yes

5. Was the information about air quality that we gave you useful to you?

   ☐ No ☐ Yes ☐ Unsure

6. If yes, how did you use it? If no, why not?

7. Was the information about air quality that we gave you easy to understand?

   ☐ Not Easy To Understand ☐Somewhat Easy ☐Easy ☐Very Easy

8. If the information was not easy to understand, in the space below, could you make suggestions on how we might improve it?

Please Turn Over

Below you will find a list of questions about outdoor air quality, air quality alert sites, and asthma. Please answer all questions. Check the best answer for each.	
9. Have you signed up for an air quality alert site such as www.airnow.gov?	☐ No ☐ Yes 2
	Why or why not? :
10. Have you changed your activities with the children you supervise based on air quality?	☐ No ☐ Yes 2
	Why or why not? :
11. Do friends, family and coworkers talk about outdoor air quality with you?	☐ Never ☐ Rarely ☐ Often ☐ Always 4
12. Before going outside, do you think about what the air quality is like?	☐ Never ☐ Rarely ☐ Often ☐ Always 4
13. Check all the sources of poor outdoor air quality from these options:	☐ Rain ☐ Clouds ☐ Bicycles ☐ Pollen ☐ Coal-fired Power Plants ☐ Trees ☐ Cars ☐ Smoking ☐ Lakes ☐ Parks 10
14. How much of a risk is air pollution to you and the children under your care?	☐ Don't Know ☐ Little Risk ☐ Some Risk ☐ Big Risk 4
15. How interested are you in learning more about air quality and its effect on health?	☐ Not Interested ☐ Some Interest ☐ Interested ☐ Very Interested 4
16. The Air Quality Index (AQI) color orange means unhealthy for groups sensitive to air pollution. Which of the following are sensitive groups to air pollution? (Check all that apply)	☐ Elderly ☐ Children ☐ Young Adults ☐ People with lung problems ☐ Teachers ☐ Factory Workers ☐ Asthmatics ☐ People who use crutches 8
17. Do you find the Air Quality Index easy to understand?	☐ No ☐ Yes 2

Thank you for completing the survey!