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PREVALENCE AND EXACERBATION OF ASTHMA WITHIN TWO COUNTIES IN EASTERN KENTUCKY

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Abstract

Background: Central Appalachia residents have one of the highest rates of serious respiratory diseases in the nation. Appalachian Kentuckians are 50% more likely to be diagnosed with adult asthma compared to the overall U.S. population. Yet, few epidemiologic studies have assessed risk factors for respiratory disease in this population. Using a community-based approach, the investigators of the Mountain Air Project (MAP), one of the largest adult cohorts from two disadvantaged communities in Central Kentucky, collected data to estimate the prevalence of asthma and assess various socioeconomic and environmental risk factors to determine their effect on asthma.

Methods: A cross-sectional epidemiologic study was undertaken of 1,190 individuals of which 972 individuals (67%) completed all requirement of the study. The inclusion criteria for participants included: 21 years and older residing in one of the two targeted counties for three years, being an English speaker, and being of any race or ethnicity. The study required the completion of an interviewer–administered questionnaire and spirometry test. Prevalence ratios and 95% confidence intervals for self-reported asthma episodes were computed for the entire cohort and then stratified by multiple characteristics including gender, income, housing type, exposure to mold, and several exposure metrics to roadway traffic, coal haul routes, coal mining, and oil and gas operations.

Results: Age, socioeconomics and environmental factors are major risk factors for asthma exacerbations. Living within a road density metric greater than 2.76 square miles was identified as a significant risk factor compared to those living less than 1.79 square miles road density (adjusted OR: 4.39, 95% CI: 1.78-10.81). Additional risks factors were identified such as living in an apartment vs. single family home (adjusted OR: 4.13, 95% CI: 1.91-8.92), younger age with those in their 40's at a higher risk than those in their 60's (adjusted OR: 3.26, 95% CI: 1.54-6.88). History of allergies and exposure to mold in the past 12 months were also found to be significant risk factors (adjusted OR: 2.34, 95% CI: 1.35-4.06 and adjusted OR 1.96, 95% CI: 1.05-3.67 respectively) based on a multivariable logistic regression model. The link between smoking and asthma exacerbation although present was not statistically significant. Asthma is a heterogenous condition and exacerbated as a consequence of a complex interaction between the environment, socioeconomics and genes; such interaction can cause airway inflammation and remodeling in susceptible individuals.

Introduction

Compared to the rest of the nation, Appalachia has significant healthcare disparities. According to the Appalachian Regional Commission Report, Appalachia has a high mortality of cardiovascular disease, cancer, chronic obstructive pulmonary disease (COPD), injury, stroke, diabetes and suicide. This alarming rate is even higher in Appalachia's rural areas and economically distressed areas. The nation's age-adjusted prevalence for COPD among adults is 5.9%; however, a study has found that 19.6% of adults aged 40 years and older met the criteria for Global Initiative for Chronic Obstructive Lung Disease definition of pulmonary obstruction (Cardarelli et al., 2021).

Appalachia encompasses thirteen states, Appalachian Kentucky was once known as the leading producer of coal in the nation until 1988. However, in recent years the overall production of coal has been drastically decreasing. In 2016, Kentucky coal production decreased by almost 30 percent compared to the prior year (Kentucky Energy and Environment Cabinet, 2019). Thus, rural counties such as Harlan and Letcher were greatly affected. For hundreds of years, the economy of Harlan and Letcher was solely based on active mining. In addition to occupational exposure from mining, these marginalized counties have numerous risks factors, including poverty, high smoking and obesity rates that have adversely affected the health of the population.

Exposure to environmental pollutants have been correlated with increased risk of respiratory diseases. Particulate matter (PM) from fossil fuel combustion increases the risk for respiratory diseases and adult asthma even at very low levels (Hendryx, 2009; Liu et al., 2020). Exposure to increased PM, either directly from natural sources, anthropogenic sources and indirectly from chemical reactions, have been associated with an increase in respiratory illnesses (Kurth et al., 2014). Identifying the environmental risk factors that exacerbate respiratory diseases such as asthma has an important public health significance. Occupational and general exposure to mines and other dust have been associated with elevated rates of respiratory diseases (Ayaaba et al., 2016). High traffic volume was also determined to be significantly associated with asthma exacerbations in adults (Mosnaim et al., 2019).

The increased incidence and prevalence of respiratory diseases in Appalachia compared with the rest of the U.S. is alleged to be the result of higher smoking rates, low socioeconomic status, and a lack of access to care. Using 2014-2016 estimates, 24.9% of adults in Letcher and Harlan smoke tobacco, well above the national prevalence of 15.5% during that time period. Other factors such as exposure to coal dusts has been well correlated with the excess in respiratory disease among retired and working coal miners (May et al., 2019).

In Harlan and Letcher counties, the prevalence of asthma has been increasing in recent years with a 21 percent asthma prevalence in Harlan and 14 percent asthma prevalence in Letcher in 2003-2005 and increasing to 29 percent in Harlan and 19 percent in Letcher in 2016-2018. These two marginalized rural counties in Central Appalachia have the nation's highest asthma burden; significantly higher than the national prevalence of asthma in adults which is 7.7 (CDC, 2020). Numerous ecological studies have established a link between environmental exposure and respiratory diseases; however, ecologic study designs limit causal inference. Furthermore, these study designs focus on groups rather than individuals (Morgensten, 1995). Due to a history of active mining processes, fine particulates including coal dust were likely released into the atmosphere, thus impacting the health of the residents of both Harlan and Letcher counties.

Asthma is a reversible chronic obstructive pulmonary disease. It is a heterogenous disease, usually characterized by chronic airway inflammation. It is defined by the history of respiratory symptoms such as wheeze, shortness of breath, chest tightness and cough that vary over time and in intensity, together with variable expiratory airflow limitation (Aaron et al., 2018). Diagnosis of asthma requires a Pulmonary Function Test, which will reveal a reduced a FEV1 and FEV1/FVC ratio (typically this ratio is between 0.75 and 0.80 in adults and greater than 0.90 in children) in addition to, an increase in FEV1 of > 12% and > 200 ml from baseline, 10-15 minutes after administration of a short acting bronchodilator. A positive bronchial challenge test, which is a decline in FEV1 from baseline >20% using methacholine or histamine, or > 15% with standard hyperventilation, is also diagnostic (Global Initiative for Asthma, 2020).

The prevalence of asthma varies widely by state and is the common complaint of many persons visiting emergency rooms nationwide. According to recent data from the Centers for Disease Control and Prevention, 19.2 million individuals over the age of 18 have asthma with an estimated 1.6 million emergency department visits with a primary diagnosis of asthma. Minorities such as black and those in the lower socioeconomic status, i.e., making less than 35,000 dollars a year are at a higher risk (Kentucky Health Facts, 2020). Thus, the prevalence is disproportionate among different groups and varies widely by occupation.

The poverty level in both counties is more than double that of the national average in the United States of America. According to the U.S. Census Bureau (2020), the poverty rate in the United States was reported at 10.5% compared to 31.1% in Harlan and 28.9% in Letcher county during the same year. In recent years accumulating evidence has shown that different environmental factors, i.e., tobacco, cooking with biomass fuels such as wood or coal and less than a high school level of education are significant risks factors for asthma exacerbation (Barry et al., 2010). However, the findings with biomass fuel for heating have been controversial, as some of the studies established a link with asthma exacerbation while others did not. Furthermore, the type of housing may lead to different respiratory outcomes (Gan et al., 2017). Due to the burden of asthma in those counties registering well above the rest of the country and the lack of studies evaluating the impact of biomass fuels for heating in the United States, we decided to evaluate the risks factors in that area that may explain this public health issue.

The aims of this cross-sectional study are:

Assess the risk factors for asthma exacerbations in the sample of rural adults.

Evaluate a set of environmental risk factors, including exposures to coal mining operations, road traffic density, coal hauls routes, and oil and gas operations to asthma exacerbations while controlling for known risk factors.

Evaluate housing type and mold exposure influence on asthma exacerbations.

The indoor air pollutants evaluated in this epidemiological study are estimated mold, cigarette smoking, environmental tobacco smoke and the use of wood/coal stoves. The Geographic Information System (GIS) exposure metrics include roadway density, distance to mining operations and oil and gas operations. This study is necessary to mitigate the gaps and focus on individuality to correlate and make a proper assessment between the exposures and adverse outcomes on an individual level while controlling for possible confounder and within group misclassification.

Materials

The Mountain Air Project (MAP) was an epidemiological cross-sectional study which was conducted from November 2015 to August 2017. It had the primary critical goal to address and reduce respiratory health disparity in Eastern Kentucky. Previous research on this topic used ecological studies which were limited by the absence of individual level quantitative exposure data for Appalachian residents.

Study Area and Population

This study was conducted in two eastern Kentucky counties: Harlan and Letcher. These counties were selected based on the presence of underground coal and surface mining activities, documented community concerns regarding the adverse health effects of mining, the high prevalence of respiratory disease and the community infrastructure for mobilizing the project. The community advisory board (CAB) recommended using "Hollows", which are small watershed containing neighborhoods of varying sizes as the most important geographic unit for individual level air sampling (May et al., 2019). The study was approved by the Institutional Review Committee of the University of Kentucky, and written informed consent was obtained from all participants in the study.

Eligibility Criteria and Enrollment of Participants

Inclusion criteria included being an adult (aged 21+) male or female residing within a household in either Harlan or Letcher counties for at least three years, being an English speaker, and being of any race or ethnicity. Eligible households consisted of single-family residences, apartments or mobile homes. One adult was recruited per household. If an adult in the household reported having asthma, COPD, black lung disease, lung cancer, or other respiratory health condition, then the priority was to recruit that person for the study interview. In the event that the preferred household member declined participation and another adult household member was eligible, that individual was subsequently recruited for the study (Cardarelli et al., 2021). As a financial incentive, forty dollars were given to each participant who completed the survey and a letter with the interpretation of their results regarding the environmental sampling using nonscientific language and literacy content maintained at an 8th grade reading level.

Geographic Site and House Sample Selection Strategy

Based on the assumption that participants living in the same hollow would be exposed to the same ambient respiratory exposure, we selected hollows as the unit of sampling. Hollows, denoted by U.S. Geologic Survey 14-digit hydrologic unit codes (HUC) for Letcher and Harlan counties, were randomly selected. Ten HUCs were selected from each of three levels of a composite exposure index representing the local concentration of potential sources of airborne particulates. These variables included: 1) miles of roadway per square mile in the HUC, 2) miles of designated coal haul routes per square mile, 3) abandoned surface mines as a proportion of HUC area, 4) active surface mines as a proportion of HUC area, 5) abandoned underground mines as a proportion of HUC area, 6) active underground mines as a proportion of HUC area, and 7) the number of oil or gas wells per square mile. The preliminary map of the selected hollows was then presented to the CAB, and the study area was expanded to reflect their recommendation to include additional areas with resource extraction in progress. HUCs found by on-the-ground inspection to have fewer than 10 homes available for sampling were eliminated and replaced with additional randomly selected HUCs. HUCs were not excluded from the sample solely owing to a lack of paved roads. HUCs were enumerated, as described elsewhere in this article.

Using GIS, mining locations were layered over hollow boundaries to assess proximity of these sites to residential locations. The maps were built using the most recent geospatial data available and were updated by direct observation and input from community members. After mapping and characterizing the hollows in the study region, four strata by high, medium, low, and no concentration of active coal mining and related activities (i.e., transport, processing) were created. A final set of 40 hollows were selected per county. Random selection of households within each enumerated HUC was made using a random number generator to identify a starting point for recruiting and then the CHW approached every nth house. This interval ranged from 1 to 5, depending on the number of homes in the HUC, so that a minimum of 10 homes were available for recruitment.

Data Collection

Community Health Workers (CHWs) who had received extensive training (40 hours of training) and credentialling process were responsible for the data collection using iPads and a RedCap data management platform. The assigned CHW scheduled an appointment, by telephone, for data collection to take place at the participant's home or another location convenient to the participant. A comprehensive survey covering demographics, health and occupational history, home environmental exposures, and health behaviors were completed for each participant with additional items for those who reported respiratory disease. The research protocol was reviewed and approved by the University of Kentucky Institutional Review Board.

Completion of the survey typically took approximately 40 minutes and focused on established and potential risk factors for respiratory health outcomes, collected data on current and past symptoms of respiratory health over the past 2 and 12 months before the survey. Questions were drawn primarily from established questionnaires, including the ISAAC questionnaire on wheezing and asthma, the Medical Research Council symptom-based questionnaire, and the Seattle Healthy Homes I baseline questionnaire (Krieger et al., 2009; Krieger et al., 2002; Krieger et al., 2005; Braun-Fahrlander et al., 1998; Valle et al., 2012). Family history of respiratory disease, allergies, chronic conditions, and eczema were obtained.

Chemical and biological environmental triggers, focusing on environmental tobacco smoke (ETS), pesticides, VOCs, dust mites, molds, rodent and cockroach feces, and animal dander; home heating (wood, coal, gas, space heaters, etc.), home cooking (electric, wood, gas, oil), indoor smoking, pets, molds, and dampness were assessed. Detailed information obtained on demographic and lifestyle factors (education, marital status, employment status, occupational exposures, dietary intake, alcohol consumption and tobacco use).

Data were electronically uploaded from the field to REDCap and reviewed by the data manager. The REDCap database is stored and backed up on servers in the UK DATAQUEST center. Data was exported via REDCap to SAS datasets. More details of the methods and materials used in this study was published elsewhere by May et al. (2019).

Results

A total of 4,291 homes were enumerated within 30 HUCs in the two counties. Originally 1,190 (individuals) agreed to participate in the study but 218 individuals did not complete the survey. Consequently, 972 (67%) individuals completed all the requirements of the study. The demographic characteristics of the study participants are given in Table 1. A total of 972 individuals were included in this analysis, comprised of 571 women (58.7 %) and 401 men (41.3%). The majority of participants were 60 years and older (37.4%), while the minority were between 40-49 years old (17.1%). More than 57% of the participants were married with 61.3 % only having a GED or high school diploma. About 26 percent of participants had less than a high school education level. Almost half of the participants (46.4%) had an annual household income of less than 10,000 dollars and about a quarter (24.4%) had an annual household income of over 50K. The majority (65.2%) lived in a single-family home and about 30% lived in a mobile home/trailer/apartment. Most participants (46.8%) were classified as obese with a BMI of 30+ and 2.5% were classified as underweight based on a BMI < 18.5. The bulk of the participants were nonsmokers (43.3%) with 32.9% reporting currently using tobacco products and 64% of the participants reported living with a cigarette smoker. 71.3% reported being employed or student; additionally, 56.2% reported having seasonal allergies and 22.4% a sinus infection in the past 12 months.

Table 2A shows the effect of the geographic metrics i.e., mines, oil/gas within HUC, coal haul roads and road category (ROADCAT) on asthma prevalence. The result of the analysis suggests that living within a certain distance of mines (abandon and active), coal haul roads and oil and gas within HUC does not increase the prevalence of asthma. However, living in HUCs where the roadway density was between 1.89 and greater than 2.76 square miles exposure was strongly associated with increased asthma episodes. The data indicate that those living on these roads were, respectively, 4.85 and 4.95 times more likely to have asthma episodes and exacerbation compared to the referent category of less than 1.89 square miles roadway density.

The prevalence of asthma episodes stratified by demographic variables are given in Table 2B. As supported by previous literature, female sex is a higher risk factor for asthma episodes and are about two times more likely to have asthma episodes than males (OR = 1.98, 95% CI: 1.15-3.41).

Individuals that are aged 40-49 have an increased risk of asthma episodes (OR 3.89, 95% CI 1.89-7.98), followed by 20-39 years (OR= 2.53, 95% CI: 1.22-5.22) and 50-59 (OR=2.17, 95% CI: 1.03-4.57). No greater risk of asthma was associated for those 60 and older. Poverty is also a risk factor for asthma episodes, but the results are statistically significant for those individuals with an income less than 10K, while people making over 50K were not affected by the outcome. People living in an apartment/duplex were 4.66 times more likely to have asthma episodes than their counterparts living in a single-family home or trailer. Having seasonal allergies were strongly associated with asthma episodes while smoking did not have any statistical significance with the outcome. However, those exposed to mold were 2.57 more likely to have asthma episodes.

Results of the multivariable logistic regression analysis are given in Table 3. Participants exposed to greater than 2.76 square miles roadway density exposure were significantly more at risk of having asthma episodes than those exposed to less than 1.89 roadway density (ROADCAT) (OR = 4.39, 95% CI: 1.78-10.81). Additionally, the participants exposed to 1.89-2.76 square miles of roadway density exposure were also at an increased risk of having asthma exacerbations than those living in less than 1.89 square miles roadway density exposure (OR = 4.2, 95% CI = 1.70-10.54). Age remained a risk factor in the multivariable analysis for asthma outcome for those 40 years of age as compared to 60 years and older (OR = 3.26, 95% CI: 1.54-6.88). Young age appears to be a risk factor for asthma exacerbation in all age groups, however the findings were not statistically significant for those 30 and 50 years of age compared to those individuals 60 years and older. However, female sex still remained a risk factor this finding was not statistically significant (OR = 1.5, 95% CI: 0.85-2.65).

According to the multivariable regression analysis, living in an apartment was an increased risk factor for asthma exacerbations compared to living in a single-family home (OR = 4.13, 95% CI: 1.91-8.92). Allergy and mold were also risk factors for the targeted outcome (OR = 2.34, 95% CI: 1.35-4.06 and OR = 1.96, 95% CI: 1.05-3.67 respectively).

Discussion

The goal of this study was to evaluate the effect of environmental risk factors on asthma episodes. In our study, we have determined that roadway density (ROADCAT) is the most important exposure followed by type of home and age, especially those who are in their 40's compared to their 60+ years old counterparts. Allergy and mold were also identified as risk factors for asthma exacerbations. Although women in the study had more asthma episodes than their counterpart males, this finding was not statistically significant in the multivariable regression analysis. Some social and environmental elements identified as risk factors for asthma episodes included poverty (income less than 10,000 dollars a year), living in an apartment vs. a home or a trailer, having seasonal allergies and exposure to mold. In investigating the series of GIS exposure metrics for various types of mining and roadway exposures, roadway density between 1.89 and greater than 2.76 square miles exposure was the most significant risk factor for asthma exacerbations.

According to the latest data from the Centers for Disease Control and Prevention (CDC, 2021), the asthma prevalence amongst women is higher than in men (8.9 vs. 6.6%). This alarming national prevalence amongst women is yet lower than the 9.03% prevalence calculated in our study. The prevalence of asthma below 100% of the federal poverty threshold (below 12,760 for a single individual) is reported to be 10.8% (CDC, 2021) which is slightly higher than the 8.74% prevalence for the income less than 10,000 dollars a year. These findings were supported in previous literature.

A limitation of our study is that we did not stratify the poverty level and income by family size, thus underestimating the true prevalence of asthma in this income range. Lastly, the current national prevalence of asthma for adults 65+ years is higher (7.8%) than that in our study (3.64% for 60+ years). This age group 65+ years appeared not to have an increased risk for asthma exacerbation, which is controversial according to data reported by Ponte et al. (2017) and the National data from the Centers for Disease Control and Prevention (2020).

Lindgren et al. (2009) reported that living close to traffic, i.e., within 100 meters of a road was associated with an increase prevalence of asthma diagnosis (OR = 1.40, 95% CI = 1.04-1.89) compared to compared to having less traffic exposure. We concur with this result as participants in medium and high tertiles for exposure to airborne pollutants appeared to have the highest risk factor to the asthma outcome. Participants in the medium tertile roadway density exposure of 1.89-2.76 square miles and those in the highest tertile > 2.76 square miles were at an increased risk of having asthma episodes (OR = 4.85, 95% CI: 2.00-11.77 and OR = 4.95, 95% CI: 2.04-12.01 respectively) compared to those living in the roadway density exposure < 1.89 square miles of airborne pollutants exposure. Thus, exposure to airborne pollutants appear to increase the prevalence and severity to asthma amongst individuals as supported by numerous studies.

Shah et al. (2018) also reported that in adults, unlike children, the prevalence of asthma and allergic disease is higher in women than men. This was replicated in our study as women had more asthma episodes and twice more likely to have the outcome than males. Previous studies such as Grace et al. (2019) have established a link between being overweight (BMI 25-29.9) or obese (BMI greater or equal to 30) and risk for developing asthma. In 2011-2014, asthma prevalence was higher in obese (11.1%) compared to overweight (7.8%) or normal weight adults (7.1%) (Grace et al., 2019). The study showed mixed results regarding the body mass index (BMI) as a risk factor for asthma. The data analysis suggests that being overweight could be protective contrary to previous studies.

Flamant-Hulin et al. (2013) reported mold exposure in homes was a risk factor for asthma symptoms in children, especially amongst children living in rural areas (OR= 3.38, 95% CI: 1.16-9.90). Similar studies by Hayes Jr. et al. (2013) have established a similar link with exposure to mold and mold sensitization associated with severe asthma. These findings are replicated in this study with mold exposure associated with more asthma episodes (OR= 2.57, 95% CI: 1.43-4.62). Mold can cause airway hyperresponsiveness and inflammation worsening asthma symptoms due to bronchoconstriction. The relationship between smoking and asthma is unclear and has mixed results. Some studies report a possible link while others do not. Siroux et al. (2000) reported that adult-onset asthma was not related to ever smoking (OR 1.07 in males and 1.02 in females). However, the study reported that current smoking is associated asthma severity with having more frequent asthma attacks (greater or equal to 1 attack daily) with OR= 2.39, 95% CI: 1.06-5.36. Hendryx et al. (2009) reported an increased incidence of current asthma and respiratory symptoms in mountain top mining areas (OR= 1.68, 95% CI: 1.11-2.54 and OR= 1.71, 95% CI: 1.35-2.15 respectively).

This study showed some mixed non-significant statistical results between active mines and abandoned mines with active mines greater than 0.00003 Square miles having a protective effect against the outcome. Ponte et al. (2017) reported that older subjects greater than 65 years of age have lower odds of atopic and eosinophilic phenotypes asthma (OR= 0.39, 95% CI: 0.24-0.64). However contrary to our findings, their study suggests that there is no association between age and the asthma outcome. Living in an apartment is a major risk factor for asthma episodes in our study. This could be a twofold issue; one could be due to a lower socioeconomic status and the other deteriorating housing conditions. Williamson et al. (1997) reported that after controlling for other confounding variables such as socioeconomics people living in damp housing have a higher risk of asthma episodes and increased severity compared to controls (Adjusted OR = 3.03, 95% CI: 1.65-5.57). Wang et al. (2014) also reported that people living in apartments have more wheeze (OR= 1.20, 95% CI: 1.02-1.41). Our study did not separate what housing types had the most mold and dampness; however, we can extrapolate that apartments due to their size, poor ventilation and deteriorating conditions are risk factors for airway hyperresponsiveness and asthma.

Limitations

This study is unique, and it is one of the few studies assessing environmental risks factors for asthma in adults. A major limitation in our study is the absence of full pulmonary function tests with bronchodilators. This would have allowed us to clearly establish the asthma diagnosis as well as classify disease severity and stratify cases. Due to high prevalence of smoking in Eastern Kentucky, it could be difficult for individuals to clearly distinguish between asthma symptoms and other non-reversible obstructive pulmonary diseases such as COPD. Secondly, the preferred priority to recruit household members with reported respiratory diseases i.e., asthma, COPD, Black lung disease, etc. Selection of those with respiratory health outcomes over healthy household members may have overestimated the prevalence of asthma calculated. Thus, this selection bias may have affected the actual true prevalence of asthma in those communities. This study cannot be generalized to conclude that one risk factor is more important in resulting in greater asthma episodes as individuals in the study had multiple exposures simultaneously. Thus, it is difficult to determine if the outcome was due to the cumulative effect of allergens or a single one. Further studies would have to be done to clearly establish the effect of every single exposure and asthma.

Asthma has major public health implications. The economic impact of asthma on the American Healthcare system continues to be rising. The direct and indirect cost of asthma were estimated to be 12.7 billion in 1998 and 19.7 billion in 2009 (Harver et al., 2010), while the rate of asthma related deaths was estimated at 11.2 deaths per million population in 2017 with a hospitalization rate of 5.9 per 10,000 population in 2016 (CDC, 2021).

According to the U.S. Centers for Disease Control, in 2014 the direct medical cost of asthma in Kentucky was up to $399 million. An additional $46 million in indirect costs were associated with missed school days, missed workdays and early death. During the same year, there were 19,678 emergency department visits with a primary diagnosis of asthma amounting to total billed charges of over $42 million. Also, in 2014, there were 5,111 hospitalizations with a primary diagnosis of asthma with total billed charges of over $150 million. The average length of an asthma hospital stay was 4.5 days with an average charge of $29,446. About 23 percent of these charges were billed to Medicaid and 28.5 percent of the patients were covered by Medicaid. This unprecedented cost and burden to the State of Kentucky and American Healthcare system could be prevented through self-management education programs, environmental factors identification and triggers awareness, implementation of policies aimed to decrease and/or eliminate substandard housing and policies and infrastructures to reduce roadway density exposure. These measures would ultimately reduce asthma morbidity and mortality, a step towards a healthier community and state, and decrease healthcare dollars. Indirect effects could also include a reduction in healthcare costs resulting in increased healthcare access and affordability over the long term.

Table 1: Characteristics of the study participants in the Mountain Air Project

	N	%
Gender		
Male	401	41.3
Female	571	58.7
Age Group		
20-39	219	22.5
40-49	166	17.1
50-59	224	23.1
60+	363	37.4
Marital Status		
Married/living as married	559	57.5
Single, Widowed, or Divorced	413	42.5
Education		
< High School	254	26.1
High School/GED	596	61.3
> High School	122	12.6
Annual Household Income		
< $10K	451	46.4
≥ $10k-24,999K	138	14.2
≥ $25K-49,999K	146	15.0
$50K+	237	24.4
Home Type		
Single Family House	634	65.2
Trailer/Apartment	288	29.6
Multi-Unit Housing	50	5.1
Body Mass Index (BMI) (kg/m^2)		
Underweight (<18.5)	24	2.5
Normal (18.5-24.9)	217	22.3
Overweight (25.0-29.9)	276	28.4
Obese (30.0+)	455	46.8
Smoking Status		
0. Nonsmoker	421	43.3
1. Current smoker	320	32.9
2. <10 years former	76	7.8
3. >10 years former	155	15.9

Employment Status		
Employed/Student	693	71.3
Unemployed/Disabled	271	28.7
Lives with cigarette smoker		
Yes	626	64.4
No	346	35.6
Have seasonal allergy in past 12 months		
Yes	546	56.2
No	423	43.5
Sinus Infection in past 12 months		
Yes	218	22.4
No	754	77.6

Table 2 A: Bivariate analysis for asthma episodes (current asthma + episodes 1-36)

	N Total	N Cases	%	OR (95%)
Abandoned mines				
(1) > 0.5	302	24	7.9	1.40 (0.75-2.62)
(2) 0.1-0.5	333	27	8.1	1.43 (0.78-2.6)
(3) <0.1	328	19	5.8	1.0-
Active mines				
(1) > 0.05	221	11	5.0	0.58 (0.29-1.16)
(2) 0.00003-0.05	296	22	7.3	0.89 (0.51-1.54)
(3) < 0.00003	446	37	8.3	1.0-
Oil and Gas				
(1) > 0.85	314	24	7.6	1.34 (0.68-2.65)
(2) 0.1-0.85	408	32	7.8	1.38 (0.73-2.64)
(3) 0	241	14	5.8	1.0-
Coal haul roads (sq miles)				
(1) > 0.5	309	26	8.4	1.23 (0.68-2.23)
(2) 0.1-<0.5	353	23	6.5	0.93 (0.5-1.72)
(3) 0	301	21	6.9	1.0-
Roadway density (sq miles)				
(1) > 2.76	335	32	9.6	4.95 (2.04-12.01)
(2) 1.89-2.76	341	32	9.4	4.85 (2.0-11.77)

(3) <1.89	287	6	2.1	1.0-

Table 2B: Bivariate analysis for current asthma episodes and demographic variables (N= 963)

	N Total	N cases	%	OR (95%)
Sex				
Male	398	19	4.77	1.0-
Female	565	51	9.03	1.98 (1.15-3.41)
Age Group				
20-39	218	19	8.72	2.53 (1.22-5.22)
40-49	164	21	12.80	3.89 (1.89-7.98)
50-59	224	17	7.59	2.17 (1.03-4.57)
60+	357	13	3.64	1.0-
Education				
< High School	250	18	7.20	1.0-
High School/GED	591	36	6.09	0.84 (0.47-1.5)
>High School	122	16	13.11	1.95 (0.96-4.0)
Income				
< 10K	446	39	8.74	2.05 (1.03-4.07)
10K-24,999K	136	10	7.35	1.70 (0.70-4.1)
25K-49,999K	146	10	6.85	1.57 (0.65-3.80)
50K+	235	11	4.68	1.0-
Home Type				
Single Family	630	41	6.51	1.0-
Mobile/Trailer	284	17	5.99	0.91 (0.51-1.64)
Apartment/Duplex	49	12	24.5	4.66 (2.26-9.61)
BMI				
Underweight	24	2	8.3	1.06 (0.23-4.89)
Normal	215	17	7.91	1.0-
Overweight	276	14	5.07	0.62 (0.30-1.30)
Obese	448	37	8.26	1.05 (0.58-1.9)
Marital Status				
Married	554	40	7.22	1.0-
Not Married	409	30	7.33	1.02 (0.62-1.66)
Employment Status				
Employed	685	52	7.6	1.0-
Unemployed	278	18	6.4	0.84 (0.48-1.5)

Seasonal Allergy				
Yes	540	56	10.4	3.38 (1.86-6.2)
No	423	14	3.3	1.0-
Smoking Status				
Nonsmokers	416	26	6.25	1.0-
Current	318	29	9.12	1.5 (0.87-2.61)
< 10 yrs. former	76	8	10.53	1.77 (0.77-4.06)
> 10 yrs. former	153	7	4.58	0.72 (0.31-1.70)
Mold in home				
Yes	116	17	14.66	2.57 (1.43-4.62)
No	847	53	6.26	1.0-

Table 3: Adjusted ORs from Multivariable Model of Severe Asthma Episodes

Effect	Unit	Estimate	95% Confidence Limits
Roadway Density (sq miles)			
> 2.76 vs. < 1.89	1.0	4.39	1.78-10.81
1.89 - < 1.89	1.0	4.24	1.70-10.54
Age			
30s vs 60s yrs. old	1.0	1.82	0.84-3.91
40s vs 60s yrs. old	1.0	3.26	1.54-6.88
50s vs 60s yrs. old	1.0	1.71	0.79-3.73
Sex			
Female vs Male	1.0	1.5	0.85-2.65
Home Type			
Mobile home vs single family	1.0	0.94	0.51-1.73
Apartment vs single family	1.0	4.13	1.91-8.92
Allergies			
Yes. vs No.	1.0	2.34	1.35-4.06
Mold			
Yes. vs No.	1.0	1.96	1.05-3.67

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