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Anna C. Barry
David M. Mannino
Claudia Hopenhayn
Heather Bush

Title

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Authors

Anna C. Barry, MPH^{1, 2}; David M. Mannino, MD¹; Claudia Hopenhayn, PhD¹; Heather Bush,
PhD¹

¹University of Kentucky, College of Public Health, Lexington, KY USA; ²University of North
Carolina, Gillings School of Global Public Health, Chapel Hill, NC USA

Contact Author

Anna C. Barry, MPH

University of Kentucky College of Public Health

(Currently at University of North Carolina, Gillings School of Global Public Health)

606 North Greensboro St. #C3

Carrboro, NC 27510

USA

acbarry@unc.edu

Telephone: 502-640-7756

Fax: 859-257-2418

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ABSTRACT:

Background: Asthma is a chronic inflammatory respiratory disease, characterized by episodic and reversible airflow obstruction and airway hyper-responsiveness and is influenced by both genetic and environmental factors.

Methods: We used the Burden of Obstructive Lung Disease (BOLD) survey to determine the prevalence of self-reported asthma in a target population of 325,000 adults aged ≥ 40 in Southeastern Kentucky. Post-bronchodilator spirometry was used to classify subjects based on lung function. Risk factors for asthma in this population, in particular indoor usage of biomass fuels, were evaluated.

Results: The overall study population was comprised of 508 individuals, with 15.5% reporting current asthma and 5.8% reporting former asthma. In this population, the following risk factors for asthma were identified: female sex, smoking, less than a high school education, increasing body mass index (BMI), and a history of cooking indoors with coal and wood. Cooking indoors with wood and coal for more than six months of one's life was shown to significantly increase the odds of reporting current asthma (OR=2.3, CI 1.1, 5.0), whereas no effect was seen from a history of heating indoors with wood and coal (OR=0.8, CI 0.4, 1.8).

Conclusions: Current or former asthma was reported by 21.3% of the adult population. A history of using biomass fuels when cooking indoors significantly increased the risk of reporting current asthma in this population.

INTRODUCTION:

Asthma is a “chronic inflammatory disorder of the airways, characterized by episodic and reversible airflow obstruction and airway hyper-responsiveness” [1] and has emerged as a major public health burden in the United States. In the US, the prevalence of asthma increased from 3% in 1970 to 7.2% in 2004 [1]. Asthma prevalence in the states ranges from 6.2% in Florida to 10.3% in Maine [2]. National data show increases in prevalence over time across all age, racial, and ethnic groups and among men and women, with an estimated 20 million people, including 13.8 million adults, reporting asthma in 2003. Between 2001 and 2003, an average of 12.3 million physician office visits, 1.8 million emergency department visits, 504,000 hospitalizations, and 4,210 deaths were recorded annually for the disease [1]. The costs associated with asthma vary depending on the study methodology, but are estimated to be as high as \$30.8 billion annually [3].

Risk factors for both the incidence and prevalence of asthma have been well documented in epidemiologic studies and range from environmental to genetic to socioeconomic. These include male sex in children and female sex in adults, parental history of asthma, early-life stressors and infections, obesity, and exposure to indoor and outdoor pollutants [4, 5]. Indoor combustion of biomass fuels produces both gases and particulate matter that have been found to affect the development and exacerbation of asthma [6]. Sources in the home include both heating devices and stoves used for cooking that utilize wood, coal, crop residues, manure, kerosene, or gas [6]. In much of the United States, kerosene heaters, fireplaces, and gas space heaters are used as secondary sources of heat, whereas in other parts of the world, burning wood and coal inside the home may represent the primary source of heating [7]. The duration of use, ventilation, age, type and condition of the device, and the size of the home influence the

concentration of emissions from cooking and heating devices in the home, leading to considerable variability in exposure [6].

The purpose of this study is to determine the association between current self-reported asthma and historic biomass fuel usage in a sample of adults 40 years and older living in Southeastern Kentucky who were interviewed to participate in the Burden of Lung Disease (BOLD) study.

MATERIALS AND METHODS:

Study Design:

Detailed information regarding the rationale and protocol of the BOLD Study has been previously published [10]. Data collected during the BOLD survey was used in the analysis of the current study. According to BOLD protocol, data from paper forms completed in the field were entered electronically into a specially designed secure web-based platform. Validated questionnaires were used to obtain information about the burden of respiratory disease in the study population [8]. The core questionnaire contained information on health status, medication use, co-morbidities, respiratory symptoms and diseases, risk factors for obstructive lung disease, health-care utilization, and activity limitation. Supplemental questionnaires contained information on indoor biomass usage and data relevant to spirometry measurements. Health related quality of life (HRQL) was determined based on the results of the Short Form-12 (SF-12) questionnaire [9]. Pre- and post-bronchodilator spirometry testing was performed on participants and reviewed for quality

Data in the BOLD study were collected from a random sampling of non-institutionalized adults 18 years of age or older from 29 counties with a source population of 325,000 in Southeastern Kentucky. A total of 15,148 study homes were identified through random digit

dialing. In 7,073 calls, individuals either could not be reached or hung up. Another 6,011 calls were ineligible due to an invalid telephone number with no forwarding information, no one in the household of eligible age to participate in the study (adults aged ≥ 40 years), the individuals in the household were institutionalized, or the individual in the household did not speak English, leaving 2064 participants eligible to provide minimal data (a series of six questions that assessed age, smoking status, respiratory disease status, and gender). Forty-seven individuals refused minimal participation, resulting in an eligible population of 2017. Of these 2017 eligible individuals willing to participate, a total of 1,046 provided only the minimal data. The remaining 971 individuals responded to the minimal data questionnaire and were willing to participate in site or home visits to complete a study questionnaire and perform pre-bronchodilator and post-bronchodilator spirometry. However, only 575 individuals actually scheduled visits and participated in the full protocol. Acceptable post-bronchodilator spirometry and full data were collected for 508 participants, which comprised the final study population in this analysis. All subjects gave written informed consent, and the study was approved by the University of Kentucky Institutional Review Board.

Data Analysis:

Demographic data included in this analysis were age, sex, and educational status. We classified study participants based on a *history* of using indoor combustion methods for heating and cooking, based on responses to the following two questions: “Has an indoor open fire with coal or coke been used in your home as a primary means of cooking for more than 6 months in your life?” and “Has an indoor open fire with wood, crop residues or dung been used in your home as a primary means of cooking for more than 6 months in your life?” In order to achieve stable estimates for analysis, individuals were classified as having a history of using “wood and

coal,” “wood or coal” or “neither wood nor coal” as the primary means of cooking/heating inside their home for more than six months of their life.

The study participants were classified into three asthma categories, (current asthma, former asthma, and never asthma) based on answers to the following two questions: “Has a doctor or other health care provider ever told you that you have asthma, asthmatic bronchitis or allergic bronchitis?” and “Do you still have asthma, asthmatic bronchitis or allergic bronchitis?”

Lung function was assessed by classifying study participants into four lung function categories based on the Global Initiative for Chronic Obstructive Lung Disease (GOLD) criteria and post-bronchodilator spirometry outcomes [11]. We used height as measured by trained research assistants and self-reported weight to calculate each subject’s body mass index (BMI). BMI measurements were then used to stratify subjects into the following categories: Non-overweight (BMI of less than 20), overweight (BMI between 20 and 24.9), obese (BMI between 25 and 29.9), and severely obese (BMI greater than or equal to 30). Health status, smoking status, and occupational exposure to dust were assessed by self-report to survey questions.

For the purposes of logistic regression, asthma status was dichotomized into ‘Current Asthma’ versus ‘Former/Never Asthma’ because a small proportion of individuals reported ‘Former Asthma.’ BMI and age were added to the regression models as continuous variables.

Data analysis was completed using SAS statistical software, Version 9.1. Descriptive statistics and frequency distributions were calculated for the eligible and studied population and χ^2 tests of independence were used to determine if there were differences between the study population and the eligible cohort. We calculated sample weights based on the demographics of the target population in Southeastern Kentucky and applied them to the eligible cohort. Bivariate analysis was conducted, using χ^2 tests for independence for categorical variables and one-way

ANOVA tests for continuous variables to determine the relationship between gender, age, smoking status, educational level, occupational exposure, BMI, health status, lung function, a history of cooking with wood and/or coal, and a history of heating with wood and/or coal with asthma status in the eligible cohort. Logistic regression was then used to examine the association between cooking and heating with coal and/or wood had on dichotomized asthma status (current asthma versus former/never asthma). The model was adjusted for age, gender, BMI, education, smoking status, and occupational exposure. Variance inflation factors were examined to verify that collinearity was absent in the variables measuring a history of cooking indoors with wood/coal and a history of heating indoors with wood/coal.

RESULTS:

Acceptable postbronchodilator spirometry and full questionnaire data were collected for 508 individuals (206 males and 302 females), which comprised the study sample for this analysis. Table 1 displays the distribution by sex, age, and smoking status of the sample and the eligible population that did not fully participate in the survey (the study population was 100% white). Comparing these two populations, the study sample only differs from the eligible population in age, with a smaller proportion individuals over the age of 70 years participating in the survey.

Sample weights were applied to the study population to reflect the target population (29 counties in Southeastern Kentucky). Table 2 displays the weighted characteristics of the total sample and stratified by self-reported asthma status. Of the total sample, 15.5% reported current asthma and 5.8% reported former asthma. Females reported having current asthma more than former and never asthma when compared to men (18.5% vs. 12.1%, $p=0.03$). Of the individuals reporting a history of biomass exposure due to cooking with both wood and coal,

27.3.% reported experiencing current asthma ($p=0.002$), while only 20.6% of individuals reporting a history of biomass exposure due to heating with wood and coal reported having current asthma ($p=0.06$). . This relationship was not seen for heating with wood and coal. Current smoking (22.8%, $p=0.010$), occupational exposure (19.0%, $p=0.05$), less than a high school education (24.6%, $p=0.03$) were also associated with self-reported current asthma. Report of asthma status was relatively consistent across each age group ($p=0.85$) and BMI category ($p=0.096$) and were found to not be associated with current asthma in this sample.

To examine the correlation between a history of heating and cooking with wood and/or coal, we evaluated the inter-group agreement between the heating and cooking variables (Table 3).

The relationship between a history of cooking and heating with wood and coal and asthma status (current asthma versus former/never asthma) was evaluated by using binary logistic regression (Table 4). When adjusted for age, sex, smoking status, education, BMI, and occupational exposure, individuals who have current asthma have 2.3 [CI 1.1, 5.0] the odds of reporting a history of cooking with wood and coal as compared to individuals who formerly or never had asthma. Current asthma was not associated with a history of heating with wood and coal ($OR=0.8$ [CI 0.4, 1.8]). Figures 1 and 2 illustrate the difference in biomass fuel usage for cooking and heating between individuals with ‘Current Asthma’ and individuals with ‘Former/Never Asthma.’ In Figure 1 we see that a greater proportion of individuals with current asthma have a history of using both wood and coal for cooking than those with former/never asthma. Figure 2 illustrates a similar trend for heating indoors with wood and/or coal, however the difference between current and former/never asthma is not as great.

DISCUSSION:

We determined the prevalence of current asthma in our sample to be 15.5%. This is higher than the adult prevalence in both the U.S. (7.2%) and in Kentucky (9%) [1, 2]. We also determined a number of risk factors are associated with asthma, including female sex, occupational exposure, less than a high school education, increased BMI, and a history of cooking indoors with wood and coal (Table 2).

In the literature, of the six studies examining the association between asthma and exposure to wood stoves used for heating or cooking, three found a positive association. In Sweden, Thorn et al. found an increased likelihood of asthma in homes where wood stoves were used for heating as compared to homes where wood stoves were not used [12]. Schei et al. determined that the use of an open fire for cooking indoors may be an important risk factor for asthma symptoms and severity in children in Guatemala [13]. Researchers have also found that exposure to biomass fuels while cooking, affects pulmonary function in asthmatics and decreases airway function and increases symptoms of bronchial asthma among non-smoking females in India[7]. Three additional studies did not find an association between asthma occurrence and the presence of a wood stove in the home [14-16].

Several studies in China have been conducted to investigate the association between asthma and heating and cooking with a coal stove [6]. One case-control study of Chinese schoolchildren found that compared to using steam heat, exposure to a coal stove for heating increased the odds of developing asthma by 50%. The same study found that children who lived in homes where coal was used for cooking without proper ventilation had 2.3 the odds of developing asthma as children who lived in households where proper ventilation was used [17]. A second study that investigated household factors and asthma in four Chinese cities found a

similar increase in risk for asthma as in the aforementioned study due to heating with coal, but did not find any association between cooking with coal and increased asthma occurrence [18].

In their review of the relationship between asthma and indoor combustion, Belanger et al. concluded that, in general, heating exposures were more consistently associated with risk than cooking exposures [6]. Secondly, exposure to burning coal in the home seems to pose a greater risk to increased asthma occurrence than wood burning in the home [6]. However, the findings in our study found that a history of cooking with biomass fuels has more of a relationship with asthma than a history of heating with wood and coal. Many of the studies dealing with the use of biomass fuels for cooking and heating are conducted in developing countries [7, 12, 16, 19], while our study focuses on a population in rural America. It is unclear from this analysis whether our results differ with those found in the published literature because of differences in the study populations or because of differences in methodology. The differences we found could be due to actual differences in patterns of biomass fuel use for heating and cooking or due to the manner in which exposure was assessed. Our study only analyzes a *history* of biomass usage in the home for heating and cooking purposes, whereas previous studies investigating the relationship between asthma and indoor biomass fuel exposure analyze current use, exposure during childhood only, or duration of exposure [6, 16].

A history of biomass fuel usage could help explain the elevated levels of current asthma that were found in this population as compared to the rest of the state and country. However, based on this study, we cannot determine the age at which respondents were exposed to indoor biomass fuels or the intensity and duration of exposure at that time. There could also be differential effects in this analysis, whereby biomass used for cooking occurs constantly, maybe several times a day, while biofuel combustion for heating may range from the main source of

heating to occasional/recreational use of a fireplace. Additionally, the effect of cooking and heating with indoor biomass fuels on asthma may differ by the season on the year as well as the age the exposure occurred [4].

Our study has several limitations. Participants were asked about both disease outcome and risk factors simultaneously, so conclusions cannot be made about the direction of causality in this sample. Furthermore, many of the findings from this study were based on self-report that were not independently validated, suggesting the possibility of reporting bias. However, the questions in this survey were not of a particularly sensitive nature and the findings regarding asthma status and history of biomass fuel usage should be relatively accurate.

The participation rate among people known to be eligible was 25.2%. Studies with low participation rates are more susceptible to selection bias because the individuals who participated in the study may not actually represent the source population. We did use weighted data to adjust the demographics of the study sample to that of the target population, but weights do not eliminate nonparticipation bias. This may lead to problems with external validity.

Finally, the BOLD survey was not designed to ask asthma-specific questions. It is a questionnaire designed to gain information about obstructive lung disease, in particular Chronic Obstructive Pulmonary Disease. Therefore, our analysis is limited by number and types of questions asked in the BOLD survey. In addition, the BOLD survey did not collect detailed information about yearly usage patterns of biomass fuel, type and condition of the device used to cook or heat indoors, and the size of the home, all of which are factors that influence the concentration of emissions in the home. It is also important to consider that respondents to the BOLD survey were asked about a *history* of biomass fuel usage for cooking and heating in the home that lasted more than six months of the respondent's lifetime. Further research is

necessary to determine if the age of exposure, length of exposure, or current exposure have an additional effect on self-reported asthma status.

CONCLUSION:

We found the prevalence of current asthma to be higher in Southeastern Kentucky than both the rest of the state and U.S. Risk factors for disease included smoking status, education, BMI, occupational exposure, and a history of cooking indoors with biomass fuel. Based on these findings, we suggest that the elevated levels of asthma occurrence in our sample could be due to differences in a history of biomass fuel usage as compared to the rest of the state and country. While the usage of biomass fuels for heating and cooking is not as common in the US as it is in other parts of the world, the findings of this study suggest this exposure still has serious consequences for the health of this population.

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REFERENCES

1. Moorman, J.E., et al., *National surveillance for asthma--United States, 1980-2004*. MMWR Surveill Summ, 2007. **56**(8): p. 1-54.
2. *Table C1, analysis by Air Pollution and Respiratory Health Branch*. 2007, Behavioral Risk Factor Surveillance System (BRFSS) National Center for Environmental Health Centers for Disease Control and Prevention.
3. Kamble, S. and M. Bharmal, *Incremental direct expenditure of treating asthma in the United States*. J Asthma, 2009. **46**(1): p. 73-80.
4. King, M.E., D.M. Mannino, and F. Holguin, *Risk factors for asthma incidence. A review of recent prospective evidence*. Panminerva Med, 2004. **46**(2): p. 97-110.
5. Lemanske, R.F., Jr. and W.W. Busse, *Asthma*. JAMA, 1997. **278**(22): p. 1855-73.
6. Belanger, K. and E.W. Triche, *Indoor combustion and asthma*. Immunol Allergy Clin North Am, 2008. **28**(3): p. 507-19, vii.
7. Behera, D., T. Chakrabarti, and K.L. Khanduja, *Effect of exposure to domestic cooking fuels on bronchial asthma*. Indian J Chest Dis Allied Sci, 2001. **43**(1): p. 27-31.
8. Buist, A.S., et al., *The Burden of Obstructive Lung Disease Initiative (BOLD): rationale and design*. COPD, 2005. **2**(2): p. 277-83.
9. Ware, J., Jr., M. Kosinski, and S.D. Keller, *A 12-Item Short-Form Health Survey: construction of scales and preliminary tests of reliability and validity*. Med Care, 1996. **34**(3): p. 220-33.
10. Buist, A.S., et al., *International variation in the prevalence of COPD (the BOLD Study): a population-based prevalence study*. Lancet, 2007. **370**(9589): p. 741-50.
11. Rabe, K.F., et al., *Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease: GOLD executive summary*. Am J Respir Crit Care Med, 2007. **176**(6): p. 532-55.

12. Thorn, J., J. Brisman, and K. Toren, *Adult-onset asthma is associated with self-reported mold or environmental tobacco smoke exposures in the home*. Allergy, 2001. **56**(4): p. 287-92.
13. Schei, M.A., et al., *Childhood asthma and indoor woodsmoke from cooking in Guatemala*. J Expo Anal Environ Epidemiol, 2004. **14 Suppl 1**: p. S110-7.
14. Noonan, C.W. and T.J. Ward, *Environmental tobacco smoke, woodstove heating and risk of asthma symptoms*. J Asthma, 2007. **44**(9): p. 735-8.
15. Eisner, M.D., et al., *Exposure to indoor combustion and adult asthma outcomes: environmental tobacco smoke, gas stoves, and woodsmoke*. Thorax, 2002. **57**(11): p. 973-8.
16. Kilpelainen, M., et al., *Wood stove heating, asthma and allergies*. Respir Med, 2001. **95**(11): p. 911-6.
17. Zheng, T., et al., *Childhood asthma in Beijing, China: a population-based case-control study*. Am J Epidemiol, 2002. **156**(10): p. 977-83.
18. Qian, Z., et al., *Factor analysis of household factors: are they associated with respiratory conditions in Chinese children?* Int J Epidemiol, 2004. **33**(3): p. 582-8.
19. Padhi, B.K. and P.K. Padhy, *Domestic fuels, indoor air pollution, and children's health*. Ann N Y Acad Sci, 2008. **1140**: p. 209-17.

Figure 1: Cooking Indoors with Biomass Fuels

Figure 2: Heating Indoors with Biomass Fuels

Table 1: Characteristics of the Eligible Population versus the Sample Population

Variable	Eligible Population Not Included (N=1510)		Study Population (N=508)		Significance
	N	% [95% CI]	N	% [95% CI]	
Sex					
Male	646	75.8% [73., 78.9]	206	24.2% [21.1, 26.9]	p=0.38
Female	1165	74.1% [71.8,76.2]	302	25.9% [23.8, 28.2]	
Age Group					
40-49	423	75.7% [72.1, 79.3]	136	24.3% [20.7, 27.9]	p<0.0001*
50-59	460	71.4% [67.9, 74.9]	184	28.6% [25.1, 32.1]	
60-69	337	71.9% [67.8, 76.0]	132	28.1% [24.0, 32.1]	
70+	290	83.8% [79.9, 87.7]	56	16.2% [12.3, 20.1]	
Smoking Status					
Current	384	74.7% [70.9, 78.5]	130	25.3% [21.5, 29.1]	p=0.56
Former	474	73.5% [70.1, 76.9]	171	26.5% [23.1, 29.9]	
Never	652	75.9% [73.0, 78.8]	207	24.1% [21.2, 27.0]	
TOTAL	1510	74.8% [72.9, 76.7]	508	25.2% [23.3, 27.1]	

* Denotes Statistical Significance

Table 2: Total Sample and Weighted Proportion of Risk Factor by Asthma Status

Variable	Total Sample (N=508)	Current Asthma (N=81)	Former Asthma (N=32)	Never Asthma (N=395)	Weighted Significance
Sex					
Male	206 (46.4%)	25 (12.1%)	7 (3.6%)	174 (83.7%)	p=0.03*
Female	302 (53.6%)	56 (18.5%)	25 (7.7%)	221 (74.4%)	
Age Group					
40-49	136 (34.4%)	21 (15.8%)	10 (6.9%)	105 (77.2%)	p=0.85
50-59	184 (26.4%)	29 (15.6%)	14 (7.1%)	141 (77.3%)	
60-69	132 (20.7%)	24 (16.6%)	6 (4.2%)	102 (79.2%)	
70+	56 (19.1%)	7 (13.4%)	2 (3.7%)	47 (82.9%)	
Smoking Status					
Current	134 (26.4%)	29 (22.8%)	12 (8.5%)	93 (68.7%)	p=0.01*
Former	172 (32.7%)	22 (10.9%)	6 (3.4%)	144 (85.7%)	
Never	202 (40.6%)	30 (14.4%)	14 (6.0%)	158 (79.7%)	
Health Status					
Excellent	49 (9.2%)	3 (5.2%)	0 (0%)	46 (94.8%)	p<0.0001*
Very Good	139 (28.7%)	9 (5.1%)	9 (5.8%)	121 (89.2%)	
Good	163 (31.4%)	29 (19.2%)	11 (5.5%)	123 (75.3%)	
Fair	109 (21.3%)	21 (19.7%)	11 (10.7%)	77 (69.6%)	
Poor	48 (9.5%)	19 (35.0%)	1 (1.3%)	28 (63.7%)	
Education					
<12	109 (22.9%)	28 (24.6%)	5 (4.0%)	76 (71.4%)	p=0.03*
12	170 (33.2%)	26 (14.7%)	11 (5.9%)	133 (79.5%)	
>12	229 (43.9%)	27 (11.3%)	16 (6.7%)	186 (82.0%)	
BMI					
<20	10 (1.9%)	1 (7.2%)	1 (6.7%)	8 (86.1%)	p=0.10
20-25	82 (16.2%)	9 (13.7%)	2 (3.2%)	71 (83.1%)	
25-30	178 (36.6%)	23 (11.9%)	8 (4.0%)	147 (84.2%)	
>30	238 (45.3%)	48 (19.3%)	21 (8.2%)	169 (72.5%)	
Occupational Exposure					
Yes	245 (51.2%)	47 (19.0%)	15 (6.4%)	183 (74.6%)	p=0.05*
No	263 (48.8%)	34 (11.7%)	17 (5.2%)	212 (83.1%)	
GOLD Stage					
Stage 1,2,3/4	100 (19.6%)	24 (23.8%)	4 (2.9%)	72 (73.4%)	p<0.0001*
Restrictive	90 (17.6%)	15 (15.5%)	13 (13.3%)	62 (71.2%)	
Stage 0	182 (36.1%)	41 (22.0%)	12 (6.4%)	129 (71.6%)	
Normal	136 (26.7%)	1 (0.5%)	3 (2.2%)	132 (97.4%)	
Cooks Indoor with wood &/or coal					
No	280 (54.3%)	36 (12.8%)	17 (5.7%)	227 (81.5%)	p=0.002*
Wood or Coal	121 (23.7%)	15 (10.7%)	10 (8.0%)	96 (81.4%)	
Wood and Coal	107 (22.0%)	30 (27.3%)	5 (3.6%)	72 (69.1%)	
Heats Indoor with Wood &/or Coal					
No	168 (33.4%)	23 (14.0%)	7 (4.1%)	138 (81.9%)	p=0.06
Wood or Coal	150 (29.1%)	19 (10.5%)	15 (8.1%)	116 (81.4%)	
Wood & Coal	190 (37.4%)	39 (20.6%)	10 (5.5%)	141 (73.9%)	
Continuous Age					
Mean (Std Dev)	57.1 (11.8)	56.7 (10.8)	55.1 (10.9)	57.3 (12.0)	p=0.60
Continuous BMI					
Mean (Std Dev)	30.5 (6.6)	31.3 (5.4)	34.4 (8.3)	30.0 (6.5)	p=0.001*
TOTAL	508	81 (15.5%)	32 (5.8%)	395 (78.7%)	

*Denotes statistical significance where $p \leq 0.05$

Table 3: Percentage Combinations Between Heating and Cooking Variables (Weighted Percentages)

	Heating with wood & coal	Heating with Coal Only	Heating with Wood Only	Heating with Neither	TOTAL
Cooking with wood & Coal	90 (18.1%)	15 (3.3%)	0 (0%)	2 (0.5%)	107 (22.0%)
Cooking with Coal Only	37 (7.3%)	28 (4.4%)	4 (0.8%)	10 (2.3%)	79 (14.8%)
Cooking with Wood Only	17 (3.3%)	5 (1.3%)	14 (3.0%)	6 (1.3%)	42 (8.9%)
Cooking with Neither	46 (8.7%)	60 (11.2%)	24 (5.1%)	150 (29.3%)	280 (54.3%)
TOTAL	190 (37.4%)	108 (20.3%)	42 (8.9%)	168 (33.4%)	508 (100%)

Table 4: Adjusted OR and 95% CIs of Self-Reported Current Asthma

Variable	Current Asthma OR (95% Confidence Intervals)
Cooks Indoor with wood or coal	
No	Reference
Wood or Coal	0.8 (0.3, 1.6)
Wood and Coal	2.3 (1.1, 5.0)*
Heats Indoor with Wood or Coal	
No	Reference
Wood or Coal	0.7 (0.3, 1.4)
Wood & Coal	0.8 (0.4, 1.8)
Sex	
Male	Reference
Female	2.0 (1.1, 3.5)*
Smoking Status	
Never	Reference
Former	0.8 (0.4, 1.5)
Current	1.5 (0.8, 2.9)
Education	
> 12	Reference
12	1.2 (0.6, 2.2)
<12	1.8 (0.96, 3.6)
BMI (Continuous)	
1 Unit Increments	1.04 (1.0, 1.1)*
Occupational Exposure	
No	Reference
Yes	2.1 (1.2, 3.8)*
Age (Continuous)	
1 year Increments	0.99 (0.97, 1.03)

*Denotes Statistical Significance