COLLEGE OF PUBLIC HEALTH
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Improving Housing Quality to Reduce Asthma Rates and Healthcare Costs in Athens-Clarke County, Georgia

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EXECUTIVE SUMMARY

Context

The prevalence of asthma and poor housing quality are growing public health concerns in the United States, as asthma incidence rates continue to increase nationwide (Pearson, Goates, Harrykissoon, & Miller, 2014). Asthma leads to a lower quality of life due to decreased productivity, health, and wellbeing, and is one of the top reasons that children miss school and adults are absent from work (CDC, 2018).

Clinical evidence shows that the existence of mold and pests in the home are linked to the presence of asthma (Belanger *et al.*, 2003). More specifically, the presence of mold in the home has been linked to the onset of asthma (Belanger *et al.*, 2003). Exposure to allergens from indoor pests and pets, nitrogen dioxide produced by gas ovens or wood burning stoves, and mold are also associated with wheezing and persistent cough among infants (Belanger *et al.*, 2003).

Athens-Clarke County faces a critical need for asthma intervention on indoor air quality. Improving housing quality by intervening on mold could reduce asthma incidence and prevalence. Moreover, mold intervention can result in a reduction in asthma's associated social costs and medical costs. Improving residential indoor air quality has the potential to increase individual and community wellbeing in Athens. This study examines the relationship between residential indoor air quality and prevalence of household asthma in Athens-Clarke County.

Research Questions

Given the link between indoor air quality and presence of asthma, our objectives were to determine whether a relationship between residential indoor air quality (the presence of mold) and asthma exists in Athens-Clarke County. Using the Athens Wellbeing Project (AWP) data, we developed two primary questions to address this relationship:

1. Is housing quality (*i.e. indoor air quality)* associated with household asthma?
2. Are the presence of household pests and mold, respectively, predictive of asthma prevalence?

Key Findings

Our analysis of households in Athens-Clarke County showed that approximately 17% of households reported at least one individual in the home with asthma, which is comparable to rates in Georgia and the United States. We also found that 9% of the county population reported mold problems in the home.

We estimate that mold is the single highest contributor to asthma prevalence even while controlling for other predictors of asthma. Those who reported mold problems in the home were 11% more likely to report asthma in the household. Reporting obesity in the home was also positively linked to the presence of asthma in the household, though not as predictive as mold.

Recommendations

Based on our analysis, we also offer the following policy recommendations to help address asthma prevalence in our community:

1. **Intervene**
    Early intervention is key to reducing the probability of asthma, as asthma most often develops in childhood (Burbank, Sood, Kesic, Peden, & Hernandez, 2017). Housing quality improvements such as air purification and childhood wellness programs can decrease the frequency of asthma in Athens-Clarke County.

2. **Test**
    Resources could be provided to assist families in testing the indoor air quality of their homes. There are home testing kits that can be purchased online to test for various allergens and pollutants, including mold. Based on an initial search, these kits can range from $82 to $215. Professional mold testing is also an option, and private firms typically provide these services.

3. **Invest**
    Investing in interventions is critical for homes with compromised indoor air quality. An example of one such investment is purchasing air purifiers, a mold control intervention. Some other options include investing in childhood health, education and outreach, school partnerships, asthma specialist recruitment, and providing accessible care.

INTRODUCTION

In the fall of 2017, a series of policy analysis papers were produced as partial fulfillment of course requirements for the Health Policy Analysis course taught by Dr. Grace Bagwell Adams in the Department of Health Policy and Management, College of Public Health at the University of Georgia. Each of these papers utilized the Athens Wellbeing Project (AWP) household survey data collected in the fall of 2016 through the winter of 2017, in addition to secondary data sources from the U.S. Census Bureau and other state and national databases. The intent of these analyses is to inform policy making at the local level in the Athens-Clarke County Community. Four policy papers were produced from the graduate seminar, covering the following topics: access to mental health services, housing quality and asthma prevalence, the underutilization of food assistance for women and children, and creation of an index to measure wellbeing.

This study examines the relationship between housing quality and prevalence of household asthma in Athens-Clarke County. The prevalence of asthma and poor housing quality are growing public health concerns in the United States, as asthma incidence rates continue to increase nationwide (Pearson, Goates, Harrykissoon, & Miller, 2014). This condition affects all ages and stages of life, and the economic burdens are substantial. Asthma leads to a lower quality of life due to decreased productivity, health, and wellbeing, and is one of the top reasons that children miss school and adults are absent from work (CDC, 2018).

In our analysis of households in Athens-Clarke County, descriptive statistics showed that approximately 17% of households reported at least one individual in the home with asthma, which is on par with rates in Georgia and the United States. We found that 9% of the county population reported mold problems in the home. Through logistic regression analysis, we found that mold is the single highest contributor to asthma prevalence even while controlling for other predictors of asthma. Those who reported mold problems in the home were 11% more likely to report asthma in the household. Educational attainment and obesity were also statistically significant, though not as predictive as mold.

Athens-Clarke County faces a critical need for asthma intervention on indoor air quality. Improving housing quality by intervening on mold could reduce asthma incidence and prevalence. Moreover, mold intervention can result in a reduction in asthma's associated social costs and medical costs. Improving residential indoor air quality has the potential to increase individual and community wellbeing in Athens.

MOTIVATION AND RESEARCH QUESTIONS

The Centers for Disease Control (CDC) reported the national prevalence of childhood asthma increased from 8.7% in 2001 to 9.5% in 2011 (Pearson, Goates, Harrykissoon, & Miller, 2014). Since 1980, the number of children with asthma and the severity of their symptoms have risen dramatically, putting stress on families and elevating the issue as a critical priority for communities, schools, and policymakers (USEPA & NIEHS, 2017).

There is an existing body of clinical evidence that shows the presence of mold and pests in the home are linked to the development of asthma (Belanger *et al.*, 2003). More specifically, the presence of mold in the home has been linked to the onset of asthma (Belanger *et al.*, 2003). Exposure to allergens from

indoor pests and pets *(e.g.,* dust mites, cockroaches, cats and dogs), nitrogen dioxide (produced by gas ovens or wood burning stoves), and mold were associated with wheezing and persistent cough among infants (children <12 months of age) (Belanger *et al*., 2003). Persistent mold affected both infants of mothers with asthma as well as infants whose mothers do not have asthma, suggesting that mold exposure contributed to their development of this condition.

Given the established empirical link between indoor air quality and incidence of asthma, our objectives were to determine whether a relationship between residential indoor air quality (the presence of mold) and asthma exists in Athens-Clarke County, and to provide recommendations for interventions. We developed two primary questions to address the relationship between housing quality and asthma prevalence in Athens-Clarke County and analyzed Athens Wellbeing Project (AWP) data to evaluate the association.

1. Is housing quality (*i.e. indoor air quality*) associated with household asthma?
2. Are the presence of household pests and mold, respectively, predictive of asthma prevalence?

AWP DATA ANALYSIS

Household survey data from the Athens Wellbeing Project (AWP) was used in this cross-sectional study. The AWP is a collaboration among the Athens-Clarke County Unified Government, Clarke County School District, Athens Area Community Foundation, Family Connection-Communities in Schools, United Way of Northeast Georgia, the Athens Housing Authority, and the University of Georgia. A community-based household survey was designed to collect information about important public health issues in Athens-Clarke county, as well as provide key stakeholders with a snapshot of resource utilization relating to education, public safety, civic vitality, and housing.[1]

Survey data were collected in the fall of 2016 through the winter of 2017 using a stratified random sample of all Athens-Clarke County residents, with the 16 Clarke County School District elementary school attendance zones representing individual strata. Four additional strata were created to represent low income and vulnerable populations, including seniors and homeless or transitional families, which might otherwise be under represented in the household sample. In total, 1,354 households completed the survey. The AWP household survey is representative of the total population at the county level. To account for variation in non-response, a sample weight was created to increase the level of representativeness of the survey.

DESCRIPTIVE CHARACTERISTICS OF HOUSEHOLDS IN ATHENS-CLARKE COUNTY

Descriptive statistics (Table 1) showed that self-reported asthma prevalence in Athens-Clarke County was 17% at the household level. We aggregated the household estimate to the county population level and estimated 7% of the Athens population suffers from asthma (margin of error +/-3 percentage points), which is comparable to the state and national rates.

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[1] The study protocol was approved by the University of Georgia Institutional Review Board and was deemed exempt from further review meeting non-research criteria (IRB Study ID #00003747).

The literature has established that both mold and pests compromise air quality and can lead to the onset of asthma (Belanger *et al.*, 2003). We found that 9% of households reported that they are aware that they have a mold problem within their home. This is a conservative estimate, as mold often goes undetected. Additionally, 19% reported pest problems within the home.

Table 1. Summary Statistics, AWP Variables of Interest.

Variable	Percentage of Households Reporting
Asthma	17.1%
Mold	9.1%
Pests	18.9%

We also estimated descriptive statistics on the asthmatic population alone (Table 2). Of those reporting mold problems in the home, 27.3% also report that someone in the home is diagnosed with asthma. Of households with a person diagnosed as clinically obese, 25.3% also reported asthma in the household. We found that 19.6% of those receiving a high school degree or less also reported asthma incidence in the home, in comparison to 13.4% with a bachelor's degree reporting asthma or 13.9% with a master's degree.

Table 2. Summary Statistics among Subsample of Asthmatic Households.

Variable	Among Households Reporting Asthma
Mold	27.3%
Pests	22.4%
Clinically Obese	25.3%
High School Degree or Less	19.6%
Bachelors Degree	13.4%
Masters Degree	13.9%

ASSOCIATION BETWEEN HOUSING QUALITY AND ASTHMA

To predict the occurrence of asthma in a household, we utilized a multivariate logistic regression model. This technique allowed us to examine the impact of mold on asthma while controlling for other factors. Results of the logistic regression model show that mold had the strongest association with asthma prevalence relative to other variables, even when controlling for pests, home ownership status, smoking, race, ethnicity, and poverty. A household reporting the presence mold in the home is 11.3% more likely to report asthma prevalence within the household.

ASSOCIATION BETWEEN OTHER FACTORS AND ASTHMA

We also found that having a household member diagnosed as clinically obese was significantly associated with asthma prevalence within the household. Households reporting obesity were 8.5% more likely to report asthma. Prior research has identified that obesity and asthma are often comorbidities (Ebell, Marchello, & O'Connor, 2017). More research is needed to examine the relationship.

Educational attainment was also significantly associated with asthma prevalence. As educational attainment increases by one unit (degree), asthma is 2.4% less likely to be reported in the household. As mentioned previously, we found through descriptive statistical analysis that there is a large gap between

asthma prevalence among those with a high school degree or less and those with secondary education. This finding suggests that intervention strategies can be targeted toward education outreach about asthma and housing quality awareness.

Table 3. Regression Results, Effect of Mold & Other Variables on Asthma.

Variable	Marginal Effects
Mold	11.3% ***
Clinically Obese	8.5% ***
Educational Attainment	-2.36% **

Note: $p < .05$ **; $p < .01$***. All data weighted using probability weights. Marginal effects provided.

In addition to issues with housing quality in the county and the onset of asthma, we found that 17% of those reporting asthma in the household were uninsured and 20% of those reporting asthma said they had trouble finding a doctor within the past year. These patients could be more likely to seek treatment in the Emergency Department (ED), which is more costly in comparison to primary or preventive care. We estimated alternative specification tests and found that trouble finding a doctor was predictive of asthma. The full results of our analyses can be found in Appendix 1.

ECONOMIC IMPLICATIONS

The are significant economic implications attached to the prevalence of asthma and residential indoor air quality in our community. The affect on our local economy includes losses in worker productivity in the form of absenteeism and presenteeism, higher medical expenditures, and lifelong impacts on developing children. Here, we examine just one area of economic impact by estimating the amount of medical costs attributable to asthma and indoor mold. Extrapolating from the AWP dataset, we estimate 7,371 residents in Athens had asthma in 2016. The average cost per person is $3,300 per year in medical expenses, resulting in $24.3 million spent in the county per year in asthma-related medical expenditures ((USEPA & NIEHS, 2017). From our analysis, we estimate that approximately 11.3% of the variation in asthma prevalence can be explained by the presence of mold in the household. Using this information, we estimate the cost of indoor mold, in terms of asthma-related medical expenditures alone, to be an approximate $2.74 million per year.

Moreover, asthma is the 10th highest reason people visit the ED in Athens-Clarke County and the rate of ED admissions for asthma is trending upward (OASIS, 2017). The average ED outpatient visit (*i.e.* average Medicaid patient estimate) for asthma treatment costs $447 (Pearson, Goates, Harrykissoon, & Miller, 2014). In 2016, there were 600 ED admissions for asthma in Athens hospitals, Piedmont Athens Regional and St. Mary's (OASIS, 2017). Taking this figure multiplied by the $447 in asthma treatment costs totals an estimated cost of $268,200 (OASIS, 2017). In the last four years (2012-2016), there were 2,800 admissions to the ED for asthma, which yields an estimated cost of $1.2 million (OASIS, 2017).

RECOMMENDATIONS

One component of this study was a review of best practices—we examined local approaches to combatting asthma and intervening on air quality. Through this, we have identified two examples of some best practices that have been implemented in other settings to improve asthma conditions:

➢ The St. Louis chapter of the Asthma and Allergy Foundation of America worked with state legislature and school authorities to supply schools with rescue inhalers that help prevent emergency department utilization and reduce school and work absenteeism (Farmer, McStay, George, McClellan, & Sennett, 2015).

➢ The Community Asthma Initiative at Boston Children's Hospital uses nurse case managers to identify asthma patients with recurring ED visits and prioritizes home education and environmental remediation based on patient risk (Farmer, McStay, George, McClellan, & Sennett, 2015).

Based on our analysis, we also offer the following policy recommendations to help address asthma prevalence in our community:

1. **Intervene**
    Early intervention is key to reducing the probability of the onset of asthma, as asthma most often develops in childhood (Burbank, Sood, Kesic, Peden, & Hernandez, 2017). Housing quality improvements such as air purification and childhood wellness initiatives can decrease the prevalence of asthma in Athens-Clarke County.

2. **Test**
    Resources could be provided to assist families in testing the indoor air quality of their homes. There are home testing kits that can be purchased online to test for various allergens and pollutants. There are also comprehensive kits that test overall air quality and detect things like volatile organic compounds, formaldehyde, carcinogens, bacteria, and allergens, in addition to mold. Based on a preliminary search, these kits can range from $82 to $215. Professional mold testing services are also an option and are typically provided by private firms.

3. **Invest**
    Investing in interventions is critical for homes with compromised indoor air quality. An example of one such investment is purchasing air purifiers, a mold control intervention. Some other options include investing in childhood health, education and outreach, school partnerships, asthma specialist recruitment, and providing accessible care.

LIMITATIONS

There are several limitations to this analysis. First, this analysis stems from a cross-sectional survey. As survey responses were taken at a single point in time, relationships described in this analysis are associative and not causal. Second, survey responses were collected at the household level, not the individual level. Thus, we are unable to make inferences or determine relationships at the individual

resident level. Third, these data are self-reported measures that introduce the potential for response bias in the sample.

CONCLUSIONS

1. Athens-Clarke County faces a critical need for intervention on indoor air quality, particularly in the areas of mold and pests. We found a link between the presence of mold and asthma in respondent households.
2. Investing in interventions such as mold control has significant economic implications for our community. Specifically, the decrease in asthma incidence and severity provide opportunities for improvements in worker productivity, school attendance, and health care spending.
3. As a result of intervention, indoor air quality would improve, leading to significant increases in individual and community wellbeing.

ATHENS WELLBEING PROJECT

The Athens Wellbeing Project (AWP) is made possible through the following community stakeholders: Athens Area Community Foundation (AACF), Clarke County School District, United Way of Northeast Georgia, University of Georgia, Athens Housing Authority, and the Athens-Clarke County Unified Government. For more on the AWP, please visit www.athenswellbeingproject.org.

Appendix 1: Full Results of Data Analysis

Table 1. Descriptive Sample Statistics, *AWP Survey 2016*

Variable	Percentage of Households Reporting	Standard Deviation
Asthma	17.1%	.377
Mold	9.1%	.288
Pests	18.9%	.392
Clinically Obese	16.0%	.362
High School Degree or Less	32.0%	1.31
Home Ownership	65.0%	.521
Smoking Prevalence	18.2%	.386
Black/African American	24.3%	.429
White	68.9%	.463
Hispanic/Latino	9.5%	.293
Poverty at 185% FPL	42.0%	.489

Table 2. Descriptive Statistics of Households Reporting Asthma

Variable	Among Households Reporting Asthma
Mold	27.3%
Pests	22.4%
Clinically Obese	25.3%
Less Than High School	20.3%
High School Degree or Less	19.6%
Associates Degree	24.3%
Bachelors Degree	13.4%
Masters Degree	13.9%
Home Owners	15.3%
Home Renters	20.8%
Smoking Household	13.7%
Black/African American	22.7%
White	15.4%
Hispanic/Latino	16.8%
Poverty at 185% FPL	18.5%
Uninsured	18%
Trouble Finding Doctor	27.4%
Medical Bills: Somewhat Worried	18.1%

Table 3. Logistic Regression Model Results, *AWP Survey 2016*

Variable	Marginal Effects	Standard Error
Mold	11.3% ***	0.054
Pests	1.74%	0.032
Clinically Obese	8.5% ***	0.037
Educational Attainment	-2.36% **	0.011
Home Ownership Status	-2.72%	0.031
Smoking Prevalence	-3.96%	0.027
Black/African American	.79%	0.059
White	-4.37%	0.063
Hispanic/Latino	1.89%	0.058
Poverty at 185% FPL	-2.57%	0.027

Note: $p < .05$ **, $p < .01$***. All data weighted using probability weights.

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