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Secondary Data Analysis

Improving Housing Quality to Reduce Asthma Rates and Healthcare Costs in Athens-Clarke County, GA

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ABSTRACT

Background: Asthma is a chronic respiratory condition that often develops from controllable environmental factors, such as poor air quality. Our study examined the relationship between mold in the home, which compromises indoor air quality, and asthma prevalence in Athens-Clarke County (ACC), Georgia.

Methods: Data from the Athens Wellbeing Project's 2016 survey of 1,354 households in ACC was employed to examine indoor air quality and asthma prevalence in ACC. We provided descriptive statistics to examine asthma prevalence and asthma predictors, including the proportion of respondents reporting mold and pest problems, smoking prevalence, and the proportion of households reporting clinical obesity. We also examined demographic characteristics including race and ethnicity, educational attainment, home ownership status, and the percent of households in poverty at the 185% federal poverty line. We then employed a logistic regression analysis to assess the relationship between asthma and housing quality.

Results: The descriptive statistics showed that seven percent of the ACC population, 17% of households, reported there was at least one individual in the home diagnosed with asthma and nine percent of the county population experienced mold problems in the home. Logistic regression analysis showed households that reported mold problems were 11% more likely to report at least one person in the household had been diagnosed with asthma. Educational attainment and obesity were also significantly associated with asthma, though not as predictive of asthma as mold.

Conclusions: Strong statistical associations were found between indoor air quality and asthma prevalence in ACC. Improving housing quality by intervening on mold has the potential to reduce asthma rates, thereby increasing individual and community wellbeing. Our results have implications for the state of Georgia and the United States, as asthma prevalence is comparable throughout. This research adds to the body of literature focusing on the link between indoor air quality and asthma.

Keywords: Asthma, housing quality, mold, Athens Wellbeing Project
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INTRODUCTION

The prevalence of asthma and poor housing quality are growing public health concerns in the United States. Asthma rates continue to increase nationwide. The Centers for Disease Control and Prevention (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 has risen dramatically, putting stress on families and elevating the issue as a critical priority for communities, schools, and policymakers (United States Environmental Protection Agency [USEPA] & National Institute of Environmental Health Sciences [NIEHS], 2017).

There is an established body of clinical evidence indicating that poor indoor air quality can cause asthma. More specifically, the presence of mold in the home has been linked to the onset of asthma. Our objectives were to determine whether a relationship between poor housing quality (*i.e.* the presence of mold) and asthma exists in Athens-Clarke County (ACC) and to provide recommendations for interventions. We employed Athens Wellbeing Project (AWP) data in a logistic regression analysis to evaluate the relationship between housing quality and asthma prevalence in ACC. Specifically, we assessed whether the presence of mold and pests in the household were associated with greater prevalence of asthma.

The AWP is a collaborative effort of the ACC local government, the Clarke County School District, the Athens Area Community Foundation, Family Connection-Communities in Schools, United Way of Northeast Georgia, the Athens Housing Authority, and the University of Georgia. The purpose of the AWP is to provide locally representative data that outlines the needs and assets of ACC to inform the planning and activities of local

organizations. The intended goal of our study was to inform policy-making in ACC to help alleviate the health and socioeconomic burdens of asthma. However, the implications of this analysis extend beyond ACC to other communities in the state and in the nation, as asthma prevalence in ACC is comparable throughout the state of Georgia and the United States. In the following sections, we review relevant literature, provide methods of analysis and results, and close with a discussion of asthma and housing quality interventions, the limitations of our study, and the implications of our findings.

Background & Literature Review

People without asthma inhale oxygen through non-inflamed bronchial tubes, promoting easy and open air-flow ("Asthma," n.d.). In asthmatics, the bronchial tube muscles tighten and thicken when triggered, clogging and inflaming air passages, resulting in labored breathing. Asthmatics may experience coughing, shortness of breath, fatigue, wheezing, chest pain, and an increased heart rate ("Asthma," n.d.). Asthma attacks can be mild to life threatening (Wagner & Steefel, 2017). For example, the Online Analytical Statistical Information System (OASIS) reported fifteen child deaths due to asthma in Atlanta, Georgia, two child deaths in Augusta, Georgia, and one child death in ACC between the years 2012 to 2016 (OASIS, n.d.). In 2014, the baseline pediatric asthma mortality death rate was 11 deaths per year (Georgia Department of Public Health [GDPH], 2017). By 2020, the GDPH aims to eliminate all pediatric deaths attributed to asthma in the state (2017).

Asthma affects all ages and stages of life, and the burdens of asthma on wellbeing are substantial. Asthma leads to a lower quality of life due to decreased productivity, health, and wellbeing, and is one of the top reasons why children miss school and adults are absent from work ("Asthma in Schools," 2017). Thus, the annual estimated economic costs of asthma in the United States is over $56 billion, including medical costs and lost school and work days (USEPA & NIEHS, 2017). The average cost per person is $3,300 per year in medical expenses with a total cost of $260,700 over the average lifetime (2017).

The causes of asthma are likely a combination of genetic and environmental factors, though more studies on effective asthma interventions are needed (USEPA & NIEHS, 2017; Gold *et al.*, 2017; Burbank, Sood, Kesic, Peden, & Hernandez, 2017). Triggers of asthma can include airborne particles such as pollen, dust mites, mold spores, pet dander or pest waste, air pollutants (*e.g.* smoke), medications, strong emotions and stress, and sulfites and food preservatives (Mayo Clinic, n.d.).

Established clinical evidence shows the presence of mold and pests in the home are linked to the development of asthma, with the most significant indoor trigger being mold (Belanger *et al.*, 2003). Indoor mold is caused by excess indoor moisture, poor ventilation, plumbing leaks and bathroom condensation, roofing problems, and window and door drafts (Gold *et al.*, 2017). Belanger *et al.* found that 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 between birth and 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 asthma. The authors point out that though many children who wheeze early in life do not develop asthma, persistent cough and early wheezing are notable risk factors for developing the condition (2003).

Triggers of asthma can lead to asthma attacks that require emergency medical care. The CDC reports asthma as the third leading cause of hospitalization for children under 15. In 2009, asthma led to roughly 480,000 hospitalizations, 1.9 million emergency department (ED) visits, and nearly nine million doctors' office visits nationwide (Pearson, Goates, Harrykissoon, & Miller, 2014). The average cost of an ED visit was $447 nationally in the year 2016 (Pearson *et al.*, 2014).

Ebell, Marchello, and O'Connor (2017) used publicly available data from the years 2011 to 2014 to evaluate the social determinants of asthma in Georgia. Data sources from the state of Georgia included the Behavioral Risk Factor Surveillance Survey (CDC), the Georgia Asthma Call-back Survey (CDC), and the Georgia hospital and ED survey (GDPH) (2017). Ebell, *et al.* found the highest rates of asthma among Black/African Americans, women, those with less than a high school education, those in low-income households (*i.e.*, annual income below $25,000), the clinically obese, and among residents living in rural areas of South and Northwest Georgia (2017). Health insurance coverage also affected asthma occurrence; those without insurance coverage for more than three years had a higher prevalence of asthma than those with insurance or those uninsured for less than six months (2017). Ebell *et al.* recommend addressing the need for affordable insurance coverage to improve asthma treatment and management (2017).

The onset of asthma and the frequency and severity of attacks can be managed by reducing exposure to triggers. Previous literature suggests (and our recommendations concur) that intervening on mold, a trigger of asthma, is a critical first step toward reducing asthma incidence and prevalence, as well as associated health complications in Athens-Clarke County and other communities.

METHODS

Sample Population Data

The Athens Wellbeing Project (AWP) utilized a stratified random sampling design to provide a representative sample of households in ACC (Bagwell, Shannon, Abraham, & Eicheldinger, 2017). The survey was administered at the elementary school attendance zone level (as defined by the Clarke County School District) in the fall of 2016. Through in-person door-to-door surveying and online surveys, the

AWP assessed household health, lifelong learning, housing, community safety, and civic vitality. These domains were chosen due to their relevance to stakeholders and community institutions. Demographic and household information collected included family size and ages of members, race and ethnicity, income, participation in assistance programs (*i.e.*, Supplemental Nutrition Assistance Program and/or Women, Infants and Children), and educational attainment (Bagwell *et al.*, 2017). The survey had a 21.5% response rate (N= 1,354) and when weighted using sampling weights was representative of the county population (+/-3% margin of error). The University of Georgia provided IRB approval for the AWP.

Statistical Analyses

We first conducted descriptive statistics to examine the data. We then estimated a multivariate logistic regression model with probability survey weights to examine the relationship between asthma and housing quality (*i.e.*, mold or pests in the home). Control variables were selected based on prior research and results from correlation tests and t-tests. We included home ownership status, smoking prevalence, whether someone in the household has been diagnosed as being clinically obese, educational attainment, race and ethnicity, and the percentage of those in poverty at the 185% federal poverty line (FPL) as controls in the model, as each were significantly associated with asthma in testing. After employing the logistic regression model, we calculated marginal effects to assess the magnitudes of associations. We found mold, obesity, and educational attainment to be significant predictors of asthma prevalence in the household. All results had a margin of error of plus or minus three percent.

We estimated alternative specification tests including a model without the college student households, though the results were not significantly different than the model including the student population, thus the latter is reported here. The student population's inclusion is also validated by their representation of the status of rental housing quality in the county. We also estimated a model including a rental payment variable to examine if housing quality varies by rental price, though we did not leave this variable in our final model due to a large amount of missing data and statistical outliers. A final alternative specification test found that trouble finding a doctor was also significantly associated with the presence of asthma in the household. All analyses were conducted in STATA version 13.0. We triangulated our findings with secondary data sources, including state and national asthma prevalence estimates from the CDC (2011) and the Kids Count Data Book (The Annie E. Casey Foundation, 2017), and found that the AWP data on asthma prevalence was comparable.

RESULTS

Descriptive Statistics

Descriptive statistics (Table 1) showed that the outcome variable of interest, asthma prevalence in ACC, was 17% at the household level. We aggregated the household estimate to the county population level and estimated that seven percent of the ACC population has asthma with a margin of error of plus or minus three percent, which is comparable to state and national rates.

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

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

	Mean (Percentage)	Standard Deviation
Asthma	.171 (17%)	.377
Mold	.091 (9%)	.288
Pests	.189 (19%)	.392
Clinically Obese	.16 (16%)	.362
High School Degree or Less	.32 (32%)	1.31
Home Ownership	.65 (65%)	.521
Smoking Prevalence	.182 (18%)	.386
Black/African American	.243 (24%)	.429
White	.689 (69%)	.463
Hispanic/Latino	.095 (10%)	.293
Poverty at 185% FPL	.42 (42%)	.489

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

Other variables included in the model as controls were obesity prevalence, educational attainment, home ownership status, smoking prevalence, race and ethnicity, and poverty at the 185% FPL. Approximately 16% of residents in the county lived in a household where a medical professional had diagnosed one of the residents as clinically obese. Thirty-two percent of respondents received a high school degree or less. We also found that 42% of county residents were living below the 185% FPL.

We then estimated descriptive statistics on the households with asthma (Table 2). Among households reporting mold problems in the home, nine percent of our total sample, 27.3% also reported that someone in the home is diagnosed with asthma. Among households with at least one clinically obese respondent, 25.3% also reported asthma in the household. Approximately 20% of those receiving a high school degree or less also reported asthma in the home, in comparison to 13.4% with a bachelor's degree reporting asthma or 13.9% with a master's degree reporting asthma. We also found disparities in race and ethnicity, income, insurance status, and home ownership status though these variables were not significant in our final model.

Table 2. Descriptive Statistics of Asthmatic Households	
Survey responses coded as Asthma=1 & X=1	**Percentage of Households with both Asthma and *X***
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 2. Descriptive Statistics of Asthmatic Households

Logistic Regression Results

Results of the logistic regression model (Table 3) showed that mold, obesity, and educational attainment were significant predictors of asthma prevalence within the home even when controlling for pests, home ownership status, smoking, race and ethnicity, and poverty. Mold had the strongest association with asthma prevalence, as an individual reporting mold in the home was 11.3% more likely to report asthma prevalence ($p<.01$).

Table 3. Logistic Regression Model Results, *AWP Survey 2016*		
	Coefficient (Robust Std. Err.)	**Marginal Effects (Std. Err.)**
Mold	.729 (.29)***	11.3% (.054)***
Pests	.132 (.23)	1.74% (.032)
Clinically Obese	.579 (.22)***	8.5% (.037)***
Educational Attainment	-.184 (.09)**	-2.36% (.011)**
Table 3. Logistic Regression Model Results, *AWP Survey 2016* (cont.)		
Home Ownership Status	-.206 (.23)	-2.72% (.031)
Smoking Prevalence	-.334 (.25)	-3.96% (.027)
Black/African American	.061 (.45)	.79% (.059)
White	-.321 (.43)	-4.37% (.063)
Hispanic/Latino	.141 (.41)	1.89% (.058)
Poverty at 185% FPL	-.206 (.22)	-2.57% (.027)
_cons	-.737 (.53)	---
		p < .05 **, *p < .01****

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

Consistent with Ebell *et al.*, we found that obesity is associated with asthma (2017). 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. Obesity and asthma are often co-occurring disorders yet more research is needed to examine this relationship.

Educational attainment was also significantly associated with asthma prevalence. As educational attainment increases by one education level (or degree level), asthma is 2.4% less likely to be reported. As mentioned previously, we found through descriptive statistical analysis that there was a large gap between asthma prevalence among those with a high school degree or less and those with secondary education.

DISCUSSION

Our results suggest that mold in the home is strongly associated with asthma prevalence in ACC. Clinical obesity and educational attainment are also associated with asthma prevalence, but to a lesser degree than mold. Additionally, those reporting asthma within the home were more likely to report having trouble finding a doctor and affording medical bills. Our findings indicate the need for targeted interventions in Georgia addressing education, healthy homes, and accessible and affordable medical care.

Asthma is a recognized public health problem that impedes the wellbeing of Georgia communities. However, the prevalence of asthma can be reduced through effective public health interventions. The CDC has funded a Comprehensive Asthma Control Through Evidence-Based Strategies and Public Health—Health Care Collaboration program in Georgia since 2001, which formed the Georgia Asthma Control Program (GACP) (GDPH, 2015). Funding is utilized in asthma management and medication accessibility, to promote asthma quality measures, and to inform policymakers about the magnitude of asthma and its costs.

In 2013, the GACP recruited stakeholders across the state to form the Georgia Asthma Advisory Coalition (GAAC). Together, the GACP and GAAC created an asthma strategic plan with a mission, "To improve asthma control and reduce its burden in Georgia by a focused commitment to policy and environmental change, education, and an integrated care delivery system (GDPH, 2013; "Breathing Easier in Georgia," 2016)." Most efforts have been made thus far in

schools. In 2012, the GACP successfully developed a curriculum (Georgia Asthma Management Education for Childcare Settings, GAME-CS) and implemented a pilot program for the continued education of child care providers and learning centers on asthma management and how to create asthma-friendly environments where over 800 school nurses received training ("Breathing Easier in Georgia," 2016). The state of Georgia has adopted laws that approved the supply and administration of auto-injectable epinephrine and albuterol in schools and Georgia's Comprehensive Asthma-Friendly School Policy has been adopted (GDPH, 2015).

For the household, the Georgia Healthy Homes and Lead Poisoning Prevention Program (GHHLPPP) of the Environmental Health Section of the GDPH and the Georgia Healthy Homes Coalition (GHHC) created a strategic plan in 2013 that includes targeted asthma interventions within the home (GDPH: Environmental Health Section, 2013). The Georgia Healthy Homes Strategic Plan aims to improve housing conditions, acknowledging that poor indoor air quality due to airborne mold spores, among other contributors, can cause asthma (2013). In 2012, the GHHLPPP began distributing educational resources on indoor air quality to the public and made resources on healthy homes topics available to Georgia public health districts (2013). The GHHLPPP also trains Environmental Health Specialists, or healthy homes specialists, as healthy homes practitioners who can assist in the identification of home hazards, including mold (2013).

Similar to the findings of Ebell *et al.*, we found asthma implications for the uninsured population and low-income families (2017). We found that 18% of those who reported they are uninsured and 27.4% of those who reported they had trouble finding a doctor within the past year also reported asthma prevalence in the home. As noted earlier, we found that trouble finding a doctor was predictive of asthma prevalence, though this variable was not included in our final model. Many of the uninsured and those who reported having trouble finding a doctor within the past year are likely seeking care in the ED, which is costlier than preventive or primary care and is indicative of unproperly managed asthma. Even once care is accessed, 18.1% of households who reported asthma also reported they were at least somewhat worried about their ability to afford medical care. We share Ebell *et al.*'s recommendation of addressing the need for affordable insurance coverage to improve asthma treatment and management (2017).

To meet this need the GDPH aims to provide asthma treatment and education to children and families of children with asthma, targeting low income families, by 2019 (GDPH, 2016). The GHHLPPP and GACP are working together to train healthy homes specialists, asthma educators, and care managers to increase the accessibility of asthma management education and to provide comprehensive care by coordinating care with primary care physicians, specialty providers, healthy homes specialists, and schools (GDPH, 2015). Healthy homes specialists are to provide education to families and assist with household trigger reduction, including home assessments and assistance providing hypoallergenic bedding and Heating, Ventilation, and Air Conditioning (HVAC) filters and High Efficiency Particulate Air (HEPA) filters (2015).

The GDPH has begun to increase access to care management organizations and/or reimbursable asthma care (2016). In 2017, Amerigroup RealSolutions, a Medicaid Managed Care Organization, partnered with the GDPH for a pilot program where enrollees are now eligible for up to four in-home asthma education and management visits, along with home environmental assessments by a certified GDPH healthy homes specialist (Amerigroup Real Solutions in Healthcare, 2017). Through the pilot program, insurance will also cover hypoallergenic bedding and families will receive tips on how to remove asthma triggers from the home (2017). This intervention, if widely adopted across Medicaid Managed Care Organizations, shows promise for alleviating concerns in the accessibility and affordability of asthma care for low income families enrolled in Medicaid and also will help to identify mold problems within homes via healthy homes specialists.

Early intervention is key to reducing the probability of the onset of asthma, as asthma most often develops in childhood (Burbank *et al*., 2017). While the GDPH has been working to implement asthma and indoor air quality programs, the interventions are mostly in the pilot and evaluation stages and have yet to achieve widespread reach. Moreover, healthy homes initiatives, in particular, face obstacles such as a lack of knowledge among policymakers causing healthy homes efforts to be low priority, a lack of healthy homes standards and the legal enforcement of standards, and a lack of collaboration and mobilized resources to improve housing quality (GDPH: Environmental Health Section, 2013). By 2018, the GDPH aims to have accomplished the creation, adoption, and enforcement of healthy homes standards in Georgia; standards are to be adopted by housing authorities and administrative entities and enforced by counties and municipalities (2013). Additionally, the GDPH aims to have launched a healthy homes campaign to disseminate knowledge about healthy homes standards in five cities or counties (GDPH, 2013). Additional resources and collaborative efforts are needed to address indoor air quality, particularly mold abatement, as assisting families in the removal of mold has not been discussed in the state's strategic plans.

We recommend local communities of Georgia acquire educational healthy homes resources from the GHHLPPP and/or local public health districts if not already in their possession and launch or reinvigorate public health campaigns to disseminate knowledge on asthma management and indoor air quality. Resources are needed to assist families in testing for mold and mold abatement, to help cover the costs of or provide rebates for HVAC/HEPA filters and air purifiers, and to provide education and outreach via schools and community partnerships. Resources are also needed to provide accessible comprehensive medical care including at-risk patient identification, connecting asthmatics to care, care

management services, and widespread access to in-home education visits and healthy homes specialists for home environmental assessments.

There are several limitations of note in this study. *First*, data are cross-sectional and provide only a snapshot in time of ACC; therefore, causal inferences could not be drawn. However, we do not have concerns of endogeneity regarding the relationship between mold and asthma—in other words, we do not have any reason to believe that asthma could be a cause of mold in the home. *Second*, self-reported health status is subject to underreporting which is a threat to internal validity. The potential underreporting likely resulted in conservative estimates of asthma prevalence in particular. *Third*, the survey instrument was administered at the household level, not the individual level, though the age distribution in the household is provided in the survey. *Fourth*, while we selected variables based on theory and prior research, there could be indicators that are explanatory of asthma prevalence that we did not account for in this study due to unobserved or omitted variables. *Fifth*, because the sample was limited to Athens Clarke-County, Georgia, generalizability is limited. However, we suggest that these results could be meaningful to other communities throughout the nation, especially those that are similar in size and characteristics.

CONCLUSIONS

Asthma is one of the most common chronic childhood diseases that impacts ACC and other communities nationwide. However, its prevalence can be reduced through effective, early intervention. Our analysis shows that mold within the home, more so than other factors, is strongly associated with asthma prevalence in ACC. Therefore, ACC faces a critical need for asthma interventions on the improvement of indoor air quality. Our results have implications for the state of Georgia and the United States, as asthma prevalence is comparable to other states and the national average, and over the last decade has been steadily increasing.

While the GACP, GAAC, and GHHLPPP are working to meet their strategic plans for asthma prevention and control, implementation is in its early stages and is limited in scope. We recommend that the state allocate additional resources to communities for local asthma management and that ACC and other Georgia communities begin to implement the evidence-based practice interventions outlined in the above entities' strategic plans, as early and immediate intervention is warranted.

Based on our findings, we recommend that intervening on mold, in particular, requires immediate action in Athens-Clarke County. As Florence Nightingale said, "the connection between the health and the dwelling of the population is one of the most important that exists (as cited in GDPH: Environmental Health Section, 2013)." Our evidence supports the importance of the connection between health and housing and highlights the implications neglecting housing quality has on wellbeing. Improving housing quality by intervening on mold can reduce asthma rates with potentially substantial savings and widespread improvements in individual and community wellbeing.

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