Generalized Linear Models in the Analysis of Active Asthma and Asthma Severity in Adults

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STAT 680B

11 May 2022

Introduction

Asthma is a chronic disease often characterized by shortness of breath, chest pain or tightness, coughing, and wheezing (U.S. Department of Health and Human Services, 2022). It affects millions of Americans per year, with the 2020 national prevalence of asthma in adults stated as 8.4% by the CDC (Centers for Disease Control and Prevention, 2022). Despite impacting so many people, there is no cure for the disease and its etiology is not well understood (U.S. Department of Health and Human Services, 2022). Although knowledge of asthma is limited, new research continues to reshape the current understanding of the disease. For instance, recent findings suggest that asthma can impact the entire respiratory tract, rather than solely the lungs (Quirt et al., 2018). The tasks of defining, diagnosing, and controlling asthma are being reconsidered in current research by means of asthma treatment plans beyond regimens of medications alone.

Asthma is often controlled through medications and action plans. Depending on the severity of the asthma and the patient's lifestyle, different types of medication can be given. These medications include those meant for daily usage that can control and prevent symptoms or ones that are used during an attack, such as an inhaler. These quick relief medications include inhaled short-acting beta2-agonists (SABAs), oral corticosteroids, and short-acting anticholinergics (National Heart, Lung, and Blood Institute, 2022). If medication is not helping with more severe asthma, then bronchial thermoplasty treatment may be of benefit. This procedure thins out the muscles along the airways by applying heat to them, which prevents the airways from narrowing (National Heart, Lung, and Blood Institute, 2022). Other than medication or procedures, creating asthma action plans is essential in monitoring symptoms. Asthma action plans should be in place for all patients with asthma so that they may have strong command of a medication regimen and practices to follow in case of an emergency. These plans are written treatment plans that identify allergens or irritants that ought to be avoided, outlines what an asthma attack looks like and what to do in the event of an attack, lists medication types and administration times, and provides contact information for emergencies and instructions on when to see a doctor or go to the emergency room (National Heart, Lung, and Blood Institute, 2022). Tools such as a peak flow meter can be included in an asthma action plan (U.S. Department of Health and Human Services, 2022). A peak flow meter measures the speed in which air comes out of the lungs when forcefully exhaling. The results from this tool can signal the early signs of worsening asthma (Cleveland Clinic, 2020). Knowledge of, and adherence to, treatment plans will serve as a basis for improved quality of life in patients with asthma.

Asthma has different impacts on each patient, resulting in variability of symptoms and treatment plans. Even with evolving treatment plans, asthma still impedes quality of life for many asthma patients (Belachew et al., 2022). Variability in asthma severity leads to differences in medication usage and availability amongst patients. Asthma can generally be managed with proper medical treatment, but it is not always readily available to patients. Patients who disproportionately suffer severe symptoms consume more health care resources, which makes it harder for less-impacted patients to get adequate medical care (Wenzel, 2005). Even in patients with regular access to medication, their health can change over time, resulting in inconsistent medication usage (Deshpande et al., 2014). On the severity of symptoms, an important distinction must be made between severe asthma and poorly controlled asthma. Poorly controlled asthma can often be managed with therapy, while severely asthmatic patients will still have symptoms regardless of whether they had treatment or not (Wenzel, 2005). Thus, researchers must be careful to not mistake symptoms of poorly controlled asthma with severe cases. Asthma causes and alternative treatments are actively being researched to improve the quality of life for impacted Americans. Some known factors impacting asthma prevalence are genetics, health characteristics, and environmental factors.

Genetics play an important role in asthma prevalence, with certain characteristics such as sex and family history having an effect. Before puberty, boys are more likely to have asthma than girls, especially severe cases. However, this trend is reversed as they get older (Subbarao et al., 2009). Additionally, boys are more likely to be hospitalized due to asthmatic symptoms during these developmental stages than their female counterparts (Subbarao et al., 2009). After puberty, girls and young women have a higher risk of asthma, while men have a larger proportion of asthma remission (Subbarao et al., 2009) (adult male asthma prevalence = 6.2%, adult female asthma prevalence = 10.4%) (Centers for Disease Control and Prevention, 2020). A meta-analysis of predicting asthma risk by family history discovered that if at least one parent has asthma, there is a significant increase in the odds of their children having asthma when compared to parents without asthma (Burke et al., 2003). In particular, when parents (mothers, especially) have asthma, their children are more likely to develop the disease (Center for Disease Control and Prevention, 2020). This phenomenon suggests that there may be a genetic component to asthma risk. In addition to genetics, certain health characteristics can impact the symptoms of asthma, especially obesity.

Most patients with severe asthma symptoms are obese, with obese patients being at a higher risk of being hospitalized for their complications compared to their leaner counterparts (Peters et al., 2019). Some of these asthma-related difficulties originate from childhood obesity, even when patients lose weight as adults. Childhood obesity has been linked to airway dysanapsis, which is a condition that creates restricted airflow (Peters et al., 2019). As a result, the respiratory system struggles to function properly and creates breathing problems. However, breathing difficulties from asthma are not limited to obese patients. Smoking can lead to breathing issues, particularly for people with asthma.

Drug usage, especially of tobacco-based products, impacts asthma prevalence and can make symptoms worse. People who smoke at least 20 cigarettes a day are more likely to suffer from asthma than non-smokers (Hylekema et al., 2007). This increased risk in asthma prevalence based on smoking status suggests genetics are only part of the picture. Since exposure to certain chemicals like tobacco can also increase asthma prevalence, it is not strictly genetic (Self et al., 2016). Smoking is not the only lifestyle choice affecting asthma rates.

Another risk factor for asthma is contact with certain environmental exposures (Subbarao et al., 2009). For instance, exposure to endotoxins may play a role in developing asthma, and the timing of exposure can pose risks as well. Further areas of interest to study include nutrition, stress, antibiotics, cleaning supplies, and other chemical exposures. Certain occupations expose individuals to chemicals that increase the risk of asthma. For example, some common occupational exposures include car paint, hairdressing products, latex, domestic and commercial cleaning supplies, and baking ingredients such as flour (Subbarao et al., 2009). Air pollutants may also affect asthma, though they are more likely to worsen pre-existing asthma than be the cause of it (Subbarao et al., 2009). Exposure to harmful products and chemicals in many of these fields can lead to health problems, which can alter a person's well-being, making them unable to complete their day-to-day activities.

Most efforts to alleviate symptoms of asthma are made by manipulating the home environment. Recent research suggests that air purifiers may decrease allergen levels and improve quality of life for patients with allergic asthma (Jia-Ying et al., 2021), and that air filtration methods in the home that leverage whole-house filtration and portable air room cleaners provide a cost-effective approach to decreasing pollutant particles in the home and thus provide clinical benefits for patients with asthma (Sublett, 2011). The Asthma Randomized Trial of Indoor Wood Smoke (ARTIS) study found in a three-arm randomized placebo-controlled trial that homes with air filtration units had overall particulate matter ($PM_{2.5}$) reduction compared to homes that had placebo filters, and were found to be more efficacious than homes that had their wood stove changed out (from older stoves to EPA-certified stoves); this reduction in particulate matter may be of benefit to people with asthma living in those homes (Ward et al., 2017).

Apart from the burden that asthma places on individuals, it also burdens the United States as a whole by interrupting the daily work and usual activities of its citizens. In some cases this may result in hospitalization, which will oftentimes impose exorbitant medical expenses on patients. This reality, along with the other financial consequences of asthma, attests to asthma's strain on the U.S. economy. In the United States, from 2008 to 2013, "asthma was responsible for $3 billion in losses due to missed work and school days, $29 billion due to asthma-related mortality, and $50.3 billion in medical costs" (in terms of 2015 U.S. dollars) (Nurmagambetov et al., 2015). Since asthma has such a strain on the nation and its citizens, we are interested in furthering research on adult asthma.

Our study is primarily interested in looking at factors associated with active asthma and its severity in adults. We will look at how factors relating to patient demographics, habits, home environments, medical history, and treatments are associated with adult asthma. Specifically, we are interested in seeing if our study corroborates current literature.

We hypothesize that certain demographic factors will have an association with active asthma. Some of the variables looked into include sex, age, BMI, and income. We are especially interested in sex since going by current research we believe women should be more likely to have active asthma than men. We are also interested in looking at personal habits, specifically smoking, as we believe smokers will be more likely to have active asthma than non-smokers. As for medical factors, we believe certain comorbidities may lead to patients having active symptoms such as other lung diseases like COPD and bronchitis. Pursuing any treatment should be better than receiving no treatment at all, so using over the counter (OTC) asthma medication may benefit patients compared to those without a medication regimen. We have similar views with asthma symptom monitoring, such as the use of tools like a peak flow meter. Finally, we are interested in the home environment. We believe that certain home features, such as air filtration systems, will be of therapeutic benefit to people with asthma, while sources of smoke (wood stoves, or second-hand smoking) may lead to symptoms of asthma. Likewise, we think living in an urban setting rather than a rural one will have a positive association with active asthma status since there may be more pollutants in the environment.

We also hypothesize that the severity of asthma disrupts the work or usual routine of patients in a manner that is predicted by recent health history, emergency and urgent care, and body composition. Severe asthma may keep patients from going to work or performing usual activities, so missed days of work or activity can be used as a proxy measure of asthma severity. Days with good overall physical health and no asthma symptoms should be negatively associated with missed days caused by the disease. Frequent emergency or urgent care services may indicate that asthma is exacerbated often enough to take a patient away from work or activity. Body composition will be measured by BMI. We hypothesize, in accordance with the literature, that with higher BMI comes a greater risk of missing work or activity caused by asthma.

Methods

Data

The dataset is a combination of the 2019 Asthma Call-back Survey (ACBS) and the Behavioral Risk Factor Surveillance System (BRFSS) Survey.

As stated in the paper's introduction, one outcome of interest is the caller's asthma status (active or inactive). For this question, we looked at explanatory variables related to demographic and physical characteristics, medicine, health and comorbidities, environment, and lifestyle factors and their association with asthma status.

Another outcome of interest is the burden of asthma on daily life, measured by the number of days missed from work or other usual activity, with predictors such as health indicators and emergency or urgent care indicators.

Survey Description

The ACBS is "an in-depth asthma survey developed and funded by the Asthma and Community Health Branch (ACHB) in the National Center for Environmental Health (NCEH)" in the United States (Centers for Disease Control and Prevention, 2023). Data collected from the ACBS is essential in capturing information about how people with asthma live. Additionally, funding can be allocated to states, cities, and schools to explain asthma and treatment plans to people in areas with high asthma prevalence. Overall, public health decisions rely heavily on data collected through the ACBS, especially if intervention can be done (Centers for Disease Control and Prevention, 2023).

The BRFSS survey is the largest telephone survey in the world and uses data it collects to analyze public health issues. They standardize a set of questions to ask respondents across all states, allowing for consistency in data analysis projects. The asthma survey is conducted with respondents from the BRFSS survey who reported having the disease. When combining the two original surveys, there are 11,248 observations and 1,108 variables. Thus, our analysis will look at a small subset of the variables in the data set provided (Centers for Disease Control and Prevention, 2023).

Eligibility is determined by whether a respondent of the BRFSS survey reports an asthma diagnosis. They complete the ACBS approximately two weeks after the BRFSS survey is administered. The ACBS questionnaire analyzes recent asthma history, health care benefits, knowledge of asthma, environmental factors, current medications, cost of care, and other aspects of daily life that may be impacted by having asthma (Centers for Disease Control and Prevention, 2023).

State health department representatives called these participants to inform them of their intentions to conduct an asthma study. The inactive asthma group calls took an average of 5 minutes, whereas the current active asthma group calls took around 15 minutes (Centers for Disease Control and Prevention, 2023).

Dataset

The ACBS dataset included 1,108 variables. However, many of these variables were not suitable for our research interests. For the analysis, we subsetted the data to only include variables pertaining to our goals based on previous research findings. These variables focused on demographics, habits, environmental factors, medical factors, and overall quality of life.

Participants

For our study, we included the ACBS participants, which were adults with asthma residing in the United States (n = 11,248).

Exclusion criteria: Regions were excluded from the study if they had more than three months without collected interviews (Georgia, Nevada, New Jersey, New York, and the territory of Puerto Rico). The 393 observations with a "refuse" in any of the subsetted data's observations were removed. Finally, the asthma status variable had three unique levels: "active", "inactive", and "not sure". However, there were only three responses for "not sure", so those observations were removed from the dataset. Removing all of these observations left the data with 10,881 observations to use for statistical analysis.

Missing data imputation

Even in this subset, there is data that we believe to be missing completely at random, which impacts our abilities to analyze the data in a way that considers the majority of patients in this data set.

We checked this missing data and found 2,191 missing cells, with high blood cholesterol having the largest amount of missing data (600). To deal with this the R package MICE (Multivariate Imputation by Chained Equations) was used for data imputation (van Buuren & Groothuis-Oudshoorn, 2011). This new imputed dataset was used for all of our statistical analysis.

Statistical Analysis

Logistic Regression - Demographic, Environmental, and Medical Factors

To model the odds of having active asthma based on characteristics related to demographic, the environment, and medical status, logistic regression was used. The logistic regression equation is given by:

$$\text{logit}(P(X)) = \beta_0+\beta_1 X_1+\beta_2 X_2+\ldots+\beta_p X_p$$

We performed best subsets model selection with BIC as the selection criterion using the bestglm package in R to choose the best fitting logistic regression model (Ishwaran & Kogalur, 2021).

Poisson Regression - Missed Days of Activity and Indicators of Physical and Mental Health

Poisson regression was used to model the number of missed days of work or usual activity. We use missed days of work or usual activity as a proxy to the severity of asthma, as asthma symptoms exacerbate poor health. The explanatory variables used in the model were the number of recent asthma symptom-free days (i.e., within the past two weeks), recent days of poor physical health (i.e., within the past 30 days), number of recent visits to the emergency room or urgent care for asthma (i.e., within the past 12 months), and BMI. The predictors (apart from BMI) were standardized to be written in terms of days per year. The Poisson regression model is given by:

$$\ln E(Y|X) = \beta_0+\beta_1X_1+\beta_2X_2+...+\beta_pX_p \, .$$

We fit a zero-inflated Poisson regression model to safeguard the analysis from inflated false positive error rates that come from overdispersion. The zero-inflated Poisson regression model is given by:

If Y = 0, then

$$P(Y = 0) = \pi + (1 - \pi)e^{-\lambda},$$

or if Y > 0, then

$$P(Y > 0) = (1 - \pi)\frac{e^{-\lambda}\lambda^{y}}{y!},$$

where $\lambda = \exp(\beta_0+\beta_1X_1+\beta_2X_2+...+\beta_pX_p)$, and the parameter π accounts for the proportion of zeros in the data. We use the Poisson regression model to predict the expected proportion of zero missed days from work or usual activity. We then compare the expected proportion to the actual proportion of people with zero missed days of work or usual activity. If these two proportions are far off from each other, the zero-inflated Poisson regression model should be used to account for overdispersion present in the data.

All statistical analysis in the present study was performed in R via RStudio.

Results

Logistic Regression

One of our goals was to look at the relationship between certain variables focusing on demographics, habits, environmental factors, and medical factors on a participant's asthma status. The logistic regression model chosen for this question included the variables sex, age groups, air purifier usage, urban vs rural, COPD, number of poor physical days in the last month, use of OTC asthma medication, and the ability to use a peak flow meter. These results are presented in Table 1. Reference groups (RG) for the categorical variables are designated within the table.

Table 1: Logistic Regression Model, all bolded variables are statistically significant at α = 0.05.

	Exponentiated Estimate (OR)	Std. Error	z value	Pr(>|z|)
(Intercept)	0.738	0.084	-3.61	< 0.001
Female (RG: Male)	1.740	0.048	11.54	< 0.001
OTC: Never took asthma medication (RG: No)	0.330	0.126	-8.77	< 0.001
OTC: Unsure	0.505	0.197	-3.48	< 0.001
OTC: Yes	1.363	0.057	5.46	< 0.001
Peak flow meter: Unsure (RG: No)	0.615	0.167	-2.91	0.004
Peak flow meter: Yes	1.694	0.051	10.36	< 0.001
COPD: Unsure (RG: No)	2.615	0.298	3.23	0.001
COPD: Yes	3.702	0.094	13.96	< 0.001
Air purifier: Unsure (RG: No)	0.859	0.264	-0.58	0.564
Air purifier: Yes	1.316	0.055	4.99	< 0.001
Poor physical health days	1.020	0.003	7.72	< 0.001
Age 35-44 (RG: < 35)	1.080	0.081	0.95	0.340
Age 45-54	1.570	0.081	5.57	< 0.001
Age 55-64	1.994	0.075	9.16	< 0.001
Age 65-74	1.898	0.074	8.62	< 0.001
Age 75+	1.458	0.086	4.36	< 0.001
Urban (RG: Rural)	1.159	0.065	2.26	0.024

An important aspect of the model is that it tells us the odds of having asthma based on how the exponentiated coefficient compares to 1. Coefficients greater than 1 indicate higher odds of having active asthma, whereas coefficients less than 1 indicate lower odds of active asthma. Thus, we can see from Table 1 that women have a higher odds of having active asthma than their male counterparts (OR = 1.740, $p < 0.001$). Age also appears to have an association, with older people being more likely to have active asthma ($OR_{45-54} = 1.570$, $p < 0.001$; $OR_{55-64} = 1.994$, $p < 0.001$; $OR_{65-74} = 1.898$, $p < 0.001$; $OR_{75+} = 1.458$, $p < 0.001$). Those who have COPD also have a much higher odds of having active asthma than those who do not have the disease (OR = 3.702, $p < 0.001$). When taking overall physical health into account, an increase in poor physical health days has a positive association with the likelihood of currently having asthma symptoms (OR = 1.020, $p < 0.001$).

As for asthma treatments, people who have never taken any form of asthma medication are less likely to have active asthma than those who have just not taken OTC asthma medication (OR = 0.330, $p < 0.001$). Those who have taken OTC asthma medication are more likely than those who have not to currently have asthma symptoms (OR = 1.363, $p < 0.001$). Patients who have been taught to use a peak flow meter have an increased odds of having currently active asthma than those who have never been taught (OR = 1.694, $p < 0.001$).

Interestingly, air purifier usage has a positive association with having active asthma. So, those who use an air purifier in their home are more likely to have active asthma than those who do not use the technology (OR = 1.316, $p < 0.001$). This may be because of some lurking variables that are connected to a higher air purifier usage and active asthma, such as living in a polluted area or having pets. Finally, the model shows that living in an urban area has an increased risk of having asthma than living in a rural one (OR = 1.159, $p = 0.024$).

Poisson Regression

Another goal of the paper was to understand the relationship between asthma severity and recent health history, emergency or urgent care, and body composition. Since the expected and actual proportions of zeroes differed from each other when fitting a Poisson regression model, a zero-inflated Poisson regression model was used. The results of the zero-inflated Poisson regression model that was produced to answer this question are summarized in Table 2, which is split into Tables 2.1 and 2.2.

Table 2.1 looks at those patients who have missed days of work or usual activity. In this component of the model, increased odds of missed days can be predicted by more poor physical health days (RR = 1.003, $p < 0.001$) and by more emergency room visits (RR = 1.082, $p < 0.001$). Decreased odds of missed days can be predicted by more asthma symptom-free days (RR = 0.996, $p < 0.001$) and by increased BMI (RR = 0.998, $p < 0.001$). Table 2.2 looks at those patients who have not missed days of work or usual activity. Increased odds of no missed days of work or usual routine are predicted by more symptom-free days (RR = 1.004, $p < 0.001$) and by more emergency room visits (RR = 1.777, $p < 0.001$). Decreased odds of no missed days of work or usual activity are predicted by more poor physical health days (RR = 0.998, $p < 0.001$) and by increased BMI (RR = 0.982, $p < 0.001$).

Table 2.1: ZIP Regression Model, all bolded variables are statistically significant at $\alpha = 0.05$.

COUNT MODEL COEFFICIENTS (Poisson with log link)

Variable	Estimate	Exponentiated Estimate	Std. Error Estimate	Z Statistic	P-value
(Intercept)	3.435	31.031	0.014	251.705	< 0.001
Symptom-Free Days	-0.004	0.996	0.00003	-126.021	< 0.001
Poor Physical Health Days	0.003	1.003	0.00002	143.997	< 0.001
ER Visits	0.079	1.082	0.001	73.957	< 0.001
BMI	-0.002	0.998	0.0004	-5.529	< 0.001

Table 2.2: Continuation

ZERO-INFLATION MODEL COEFFICIENTS (Binomial with logit link)

(Intercept)	1.282	3.603	0.106	12.087	< 0.001
Symptom-Free Days	0.004	1.004	0.0002	23.997	< 0.001
Poor Physical Health Days	-0.002	0.998	0.0002	-10.510	< 0.001
ER Visits	0.575	1.777	0.039	-14.590	< 0.001
BMI	-0.018	0.982	0.003	-5.897	< 0.001

Discussion

The primary interests in this study were to look at factors associated with active asthma and asthma severity in adults. For the first focus, we wanted to see how elements relating to patient demographics, habits, home environments, and medical history and treatments were associated with active asthma. When looking at demographic factors, only age and sex were included in the model. We hypothesized women were more likely to have active asthma than men. This hypothesis was based on the literature discussed in the introduction of the paper. These results did corroborate with previous research. For smoking, we hypothesized smokers would be more likely to have active asthma than non-smokers. However, even after trying to include it in different models it was shown that smoking was not significant, and it was excluded from the final model. Our model shows no association with smoking and asthma status, which goes against current literature and our hypothesis. A similar conclusion was made for wood stove usage and indoor smoking. The results for air purifier usage also went against our hypothesis. Based on previous literature, we believed that air purifier usage should help alleviate asthma. However, the logistic regression model showed that air purifier usage was associated with an increased likelihood of active asthma symptoms. Taking into account the literature, one reason for these results could be that asthma status affects the decisions people make on what they want in their home environment. Since air purifiers are viewed as tools that help alleviate asthma symptoms, those with active asthma may be more interested than those with inactive asthma in using them.

When looking at the medical factors, our model does support the hypothesis that people with other lung diseases are more likely to have active asthma. This is shown by the participants with COPD. However, the results for OTC medication and the ability to use a peak flow meter did not agree with our hypotheses. We believed that the usage of OTC asthma medication and peak flow meters was better than no treatment at all. However, our results showed that usage of OTC asthma medication at some point in time and knowledge of how to use a peak flow meter had positive associations with current active asthma. Needing to use asthma medication, even just OTC medication, and having to be taught how to use asthma monitoring tools may constitute a threshold that indicates more severe asthma. Thus, those with more severe asthma may be more likely to still have the active symptoms compared to those with less severe asthma.

For our second focus, we studied how recent health history, visits to emergency or urgent care, and body composition were associated with asthma severity. This was of interest to us because of the relevant literature regarding lost wages and high healthcare costs. Our model found BMI to be significant in predicting asthma severity. Specifically, patients with higher BMI are less likely than patients with lower BMI to deviate from their routines due to their asthma complications. These results go against our hypothesis. This discovery runs against previous research on the diseases, which found that obese asthma patients are at a high risk of having severe asthma symptoms, often resulting in hospitalization. With regards to emergency or urgent care, however, the literature is corroborated since this type of care significantly predicts missed days of work or activity. Also, good health indicators significantly predict a decreased risk of missing days of work or activity, while the reverse is true for poor health indicators. These findings suggest that regular healthcare can reduce the need to miss work or other usual other activity, so patients should be monitoring their overall health to reduce the burden asthma causes to themselves and to the nation.

Limitations

Survey methodology is subject to various biases, with the most common being response bias and nonresponse bias. Response bias in this study may take the form of answering questions favorably or refusing to answer (or untruthfully responding to) sensitive questions (Qualtrics, 2023). Nonresponse bias may occur if certain members of the population are systematically missed (Qualtrics, 2023). For instance, if representatives from the ACBS conducted surveys during a part of the day when most asthma patients are working or going about their usual routine, these patients might be excluded from representation in the survey. In addition, for questions that require recalling memories, some patients may misremember certain facts that then introduce errors into the collected data (Qualtrics, 2023).

The ACBS did not collect data during certain months, so seasonality for any phenomena considered by this study may not be apparent (ACBS History and Analysis Guidance, 2019). This might cause issues since asthma may be more active during certain times of year, especially for those triggered by allergens. Further, while the dataset may contain a large amount of variables, many of them were primarily composed of missing values. As such, imputation would not be reliable for inference. Observations that are dropped, or have responses of refusal or uncertainty detract from inference and may even bias it. Since we used data imputation methods, our results may be affected. A sensitivity analysis showed some slight differences in our second model for imputed data versus the one without imputations. Specifically, the non-imputed model had BMI as an insignificant explanatory variable for the number of missed days of work or usual activity, while the imputed model showed BMI as significant. These inconsistencies should be taken into consideration when analyzing the results and interpretation.

While the ACBS and BRFSS survey offer a large variety of different variables, there are still areas lacking in the data. Genetic information such as family history could have been used for analysis, but it was missing from the surveys. While there is some employment information, there could have been more on their actual job title and industry. Also, the survey lacked environmental exposures because of the nature of the survey. Different, more community-based data would be able to provide more insight on environmental factors.

Future Work

There have been significant advancements made over the years in the understanding and management of asthma. However, there are still many areas left to investigate. Our research looked at individual-based data in areas focusing on smoking habits, medical history and asthma management, demographics, and home environments. Future asthma studies should continue to focus on addressing these gaps in how asthma is understood. Some such areas could include genetics and environmental effects.

Researchers can investigate more community-based data to gain a communal understanding of asthma that would be juxtaposed against the personal, individualistic understanding of asthma gathered in the present study. Through this community-based research, researchers could focus more on environmental effects such as air pollution, chemical exposures, and allergens, where different geographic regions may have different levels of exposures of these types.

Another avenue of research would be to do a longitudinal study rather than a survey. An advantage of a longitudinal study is that it can determine how health changes over a time for a group of people while accounting for the correlation in measurements within each patient. Ideally, many identical twins can be used for the study to control for genetic effects. Researchers can then investigate active asthma status and see how certain medications and treatment plans can compare to others to see if some are better than the others. Additionally, participants can record asthma symptoms daily, which can be used to assess whether asthma seasonality is an issue.

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