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Health Disparities Surrounding Air Quality and Asthma

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☒ By checking this box, I indicate that my mentor has read and reviewed my draft proposal prior to submission

Abstract

Introduction: Asthma is a prevalent disease in the US in both children and adults. Studies in the past have found disparities in asthma prevalence among different races in the United States as well as between gender. *Objective:* Compare asthma prevalence among racial and ethnic groups in the us, as well as gender, in the United States in both children and adults in the years of 2011 and 2014. Additionally, to see if there is a correlation between air quality, measured in $PM_{2.5mm}$, and asthma prevalence in different racial groups and genders in both children and adults. *Methods:* Asthma prevalence data from 2011 and 2014 were obtained from the CDC National Environmental Public Health Tracking Network. Air quality data from 2011 and 2014 were obtained from the Environmental Protection Agency. Data was analyzed with ANOVA and Post-hoc tests, and Pearson correlation testing using SPSS. *Results:* Preliminary results from the ANOVA test suggest disparities among racial and ethnic groups, and gender in both children and adults, with $p < .05$. Pearson correlation for racial and ethnic groups, gender, and air quality show a weak to no correlation, <.3, among adults in 2011 and 2014. Pearson correlation for racial and ethnic groups, gender, and air quality show varying degrees of correlation, among children in 2011 and 2014. Results indicate further research should be conducted to determine the extent of asthma disparities between racial and ethnic groups, as well as gender, in both adults and in children.

Key Words: Asthma, Health Disparities, Air Quality

Introduction/Literature Review

Asthma diagnosis are common in the US, with 7.7% of adults and 7.5% of children self-reporting they have been diagnosed with asthma by a physician.[1,2] These percentages have been

growing in the past decades, and with them the amount of money being spent on healthcare to treat asthma. In 2007, the economic burden of asthma in the U.S. was reported to be $56 billion, in comparison it was reported that in 2013 the economic burden of asthma totaled $81.9 billion dollars in the US.[3,4] With these increasing rates of prevalence and cost, it is important to discuss the asthma disparities between different racial groups. The Asthma and Allergy foundation of America put out a groundbreaking report that detailed the disparities; most notable is that 7.7% of Black children have asthma compared to the 5.3% of white children with asthma, and the 4.2% of Hispanic children with asthma.[5] Similarly, it found a prevalence rate of 9.3% among Blacks and 7.6% among Whites, and 5% among Hispanics.[5] However, this 2005 report and most papers relating to this subject are outdated. Very little research has been done in the last decade to understand how these disparities have evolved. Akinbami, et al detailed the continued increase in prevalence in asthma relating to children and the racial disparities associated with it up until 2010, and reaffirmed that trends post 2010 had yet to be described.[6] It is also important to note that there are disparities in the prevalence of asthma among genders, with women having higher rates of asthma than men in adults aged 18 and older, and boys having higher rates of asthma than girls in children under 18 years of age.[1,2]

While asthma prevalence rates in the US have consistently gone up, air quality measured in $PM_{2.5}$, which is the amount of particulate matter that is less that 2.5 micrometers in the air, has varied in the US across the years. From 1980 to 2018, air pollution decreased by approximately 68%, however there are still approximately 137 million people living in counties with pollution levels above national standard.[7] Specifically, 38.2 million people live in counties where the $PM_{2.5}$ levels are above the national standard.[7] Studies measuring the effects of asthma and $PM_{2.5}$ levels have had varied results, however a systematic review conducted by Fan et al.[8] found an

increase in emergency department visits by asthmatic patients when $PM_{2.5}$ levels were increased. Ścibor et al.[9] found a correlation of decreased quality of life in patients who had asthma and were exposed to higher levels of $PM_{2.5}$ than their study participants.[9] Lastly, Burbank et al described how exposure to different pollutants, including $PM_{2.5}$, has been linked with asthma exacerbations and wheezing episodes in children.[10]

Given this information on how $PM_{2.5}$ affects health, it is worthwhile to investigate how air quality levels during different years might relate to asthma prevalence among different groups. Since asthma prevalence has disparities already associated with it, it would be worth-while to assess how air quality plays a role. If air quality plays a role in the disparities surrounding asthma prevalence, further research can be done to try to address aspects of this disparity. Assessing if there is any correlation with air quality could allow for the further study of other factors that might affect health disparities among asthmatic patients. This could potentially lead to a reduction of health disparities in the US as it relates to asthma, and to better health outcomes.

Research Questions

How is air quality, measured in $PM_{2.5}$, related to the prevalence of Asthma nationwide by state, during the years of 2011 and 2014?

1. How does the prevalence of Asthma differ in adults and children by ethnicity?

2. How does the prevalence of Asthma differ in adults and children by gender?

3. How is air quality, measured in $PM_{2.5,}$ correlated to the prevalence of Asthma in adults by ethnicity?

4. How is air quality, measured in $PM_{2.5,}$ correlated the diagnosis of Asthma in adults by gender?

5. How is air quality, measured in $PM_{2.5}$, correlated to the diagnosis of Asthma in children by ethnicity?

6. How is air quality, measured in $PM_{2.5,}$ correlated to the diagnosis of Asthma in children by gender?

Methods

Context/Protocol

Data for the paper was pulled from the CDC National Environmental Public Health Tracking Network (NEPHTN). The air quality data used by the NEPHTN was gathered from the Environmental Protection Agency (EPA). The EPA gathered the data from air quality Federal Reference methods monitors across the continental US. Complete data monitoring included year, state, county FIPS code, total county population, population with monitors, population without monitors, number of days above benchmark (default NAAQS), person-days above benchmark (default federal NAAQS). Data collected from the EPA was from 2001-2014; the data used in this paper is from the 2011-2014. The asthma prevalence data was pulled by the NEPHTN, which collected it from the Behavior Risk Factor Surveillance Survey (BRFSS). The BRFSS data for adult and child prevalence of asthma from 2011-2014 collected data by phone, landline and cellphone, it was a random-digit-dialed survey of civilians 18 years or older. The answers were self-reported to the question if physicians had ever diagnosed them or their child with asthma.

Data Collection

For research question one, I will be including Hispanic, Black, White, Multi-Racial, and Other populations as the ethnicities for adults in the years of 2011 and 2014 who self-reported to have been diagnosed with asthma by a physician. I will also be including White, Black, White, and Other populations as the ethnicities for children in the years of 2011 and 2014, I will be excluding Multi-Racial populations as the data was not available for analysis for this population. Data included in the project includes anyone who self-reported that their child had received a diagnosis of asthma from a physician.

For question two, I will be including all asthma prevalence data for males and females during the years of 2011 and 2014. Air quality measured in $PM_{2.5}$ data used for the rest of the research questions will be for the years of 2011 and 2014. All states who have reported asthma diagnosis to the BRFSS will be included in the analysis. All data from the years of 2012 and 2013 will be excluded from the analysis.

Data Analysis

A one-way analysis of variance (ANOVA) was conducted to compare the prevalence of asthma among racial and ethnic groups, in both children and adults, in the US during the years of 2011 and 2014. Additionally, an ANOVA was conducted to compare the prevalence of asthma among genders in both children and adults during the years of 2011 and 2014. Post hoc analysis were performed for all ANOVA tests comparing more than 2 variables. Pearson correlations were conducted to compare the prevalence of asthma among each gender and ethnicity and how it relates to the air quality in $PM_{2.5}$ in the corresponding years.

Results

Post hoc tests revealed significant differences between racial and ethnic groups among both children and adults across both years. Among adults (Table 1), significant differences ($p<.001$) were present between all racial groups compared to the multi-racial group, as well as Hispanic and Black populations in 2011 ($p< .05$) and 2014 ($p=.001$). Other statistically significant differences in adult populations include White and Black populations ($p<.05$) during both years, and Black and Other populations ($p<.05$) across both years.

Table 1: Asthma prevalence among adults during the years of 2011 and 2014

	2011		2014	
Race/Ethnicity	**N**	**Mean**	**N**	**Mean**
Hispanic	38	13.51 (5.1)	39	12.99 (4.6)
Black	38	16.31 (3.1)[a]	38	17.15 (3.6)[h]
White	51	13.34 (1.6)[c]	51	13.52 (1.5)[c]
Other	39	13.34 (3.8)[d]	42	14.03 (4.7)[d]
Multi-Race	38	24.61 (5.6)[befg]	42	23.24 (6.4)[befg]

[a] = statistically significant difference between Hispanic and Black populations at the .05 level
[b] = statistically significant difference between Hispanic and multi-racial populations at the .001 level
[c] = statistically significant difference between Black and White populations at the .05 level
[d] = statistically significant difference between Black and Other racial populations at the .05 level
[e] = statistically significant difference between Black and multi-racial populations at the .001 level
[f] = statistically significant difference between White and multi-racial populations at the .001 level
[g] = statistically significant difference between Other and multi-racial populations at the .001 level
[h] = statistically significant difference between Hispanic and Black populations at the .001 level.

Table 2: Asthma prevalence among children during the years of 2011 and 2014

	2011		2014	
Race/Ethnicity	**N**	**Mean**	**N**	**Mean**
Hispanic	11	14.97 (4.8)	20	14.59 (4.84)
Black	6	22.92 (3.1)[a]	38	21.48 (4.7)[a]

White	16	13.34 (1.6)[b]	51	11.81(2.1)[b]
Other	8	13.34 (3.8)[c]	42	14.63 (4.2)[c]

[a] = statistically significant difference between Hispanic and Black populations at the .001 level
[b] = statistically significant difference between Black and White populations at the .001 level
[c] = statistically significant difference between Black and Other populations at the .001 level

Table 3: Asthma prevalence among male and female adults during the years of 2011 and 2014

	2011		2014	
Gender	**N**	**Mean**	**N**	**Mean**
Male	51	11.57 (1.4)	51	11.57 (1.6)
Female	51	15.54 (1.9)[a]	51	15.99 (1.9)[a]

[a] = statistically significant difference between male and female at the .001 level

Table 4: Asthma prevalence among male and female children during the years of 2011 and 2014

	2011		2014	
Gender	**N**	**Mean**	**N**	**Mean**
Male	16	15.26 (2.8)	36	16.22 (3.3)
Female	16	11.39 (2.3)[a]	36	11.86 (3.6)[a]

[a] = statistically significant difference between male and female at the .001 level

Post hoc tests revealed a statistically significant difference among children (Table 2) of all racial groups compared to Black populations ($p \leq .001$) in both 2011 and 2014. ANOVA revealed a statistically significant difference between both genders in adults (Table 3) during 2011 ($F_1=142.89$, $p<.001$) and 2014 ($F_1=165.72$, $p<.001$). ANOVA test revealed a statistically significant difference between both genders in children during 2011 ($F_1=18.79$, $p<.001$) and 2014 ($F_1=28.71$, $p<.001$).

Pearson correlation showed a moderate correlation (ρ=0.60) between air quality measured in $PM_{2.5}$ and asthma prevalence in adult Hispanic populations during 2011 and a weak correlation (ρ=0.34) during 2014. Correlations between air quality and asthma prevalence among Black adult populations were weak in 2011 (ρ=0.43) and no correlation was found in 2014. Among adult White populations a weak correlation with air quality was found in 2011 (ρ=0.43) and no correlation was found in 2014. No correlation between air quality and asthma prevalence was found in the Other and Multi-Racial populations in both 2011 and 2014.

Pearson correlation showed only a weak correlation between adult males and air quality in 2014 (ρ=0.36), no other correlations were determined in the years of 2011 and 2014. Pearson correlation showed a weakly positive correlation (ρ=0.45) between air quality and Black child populations in 2011, and no correlation in 2014. A weakly negative correlation (ρ= -0.47) was found between air quality and Hispanic child populations in 2011 and no correlation was found in 2014. No correlation was found between White child populations and air quality in 2011 and a weakly negative (ρ= -0.45) correlation was found in 2014. No correlation was found between Other child racial populations and air quality in either 2011or 2014. No correlations were found between air quality and gender among children in either 2011 or 2014.

Discussion

Statistical analysis of the data revealed significant differences between racial and ethnic groups in both adults and children as shown in tables 1 and 2. These results are not surprising, as previous studies and reports had found disparities in asthma prevalence in both children and

adults.[5] Most notably, the Asthma and Allergy Foundation report also presented differences in asthma prevalence in racial and ethnic group in children.[5,6] In their report they used BRFSS data from 2002, which revealed that Black children had a prevalence rate of 7.7.% compared to the 5.3% of White children, and 4.2% of Hispanic children that had asthma. Data used in this report was also collected from the BRFSS and revealed a similar picture regarding disparities, but with much higher prevalence rates. The new data showed that asthma prevalence had risen in all racial and ethnic groups, with Black children having a prevalence of 22.4% (2014) compared to 11.8% (2014) of White children and 14.5% (2014) of Hispanic children. This upward trend in prevalence is concerning, especially since recent studies have correlated childhood asthma to increased obesity rates, decrease in general health status, and missed worked and school days among young adults.[11] Additionally, asthma has been shown to be correlated to recurrent pneumonia infections and an increased risk of developing chronic obstructive pulmonary disease (COPD).[12] COPD is one of the major components of chronic lower respiratory diseases, which is the 4th leading cause of death in the U.S.[13]

Similarly, the Asthma and Allergy Foundation's report found a prevalence rate of 9.3% among Black adults and 7.6% among White adults, and 5% among Hispanic adults. [5] Like the child prevalence data collected from BRFSS on asthma prevalence, adult asthma prevalence has also increased as shown in Table 1. The largest increase was seen among Hispanic populations with a prevalence of 12.9% (2014) compared to the 5% (2002) found in the Asthma and Allergy Foundation report. Black asthma prevalence also increased to 17.1% (2014), as well as an increase in White populations to 13.5% (2014). Increasing rates of asthma prevalence are concerning due to the fact that having asthma as an adult, especially when developed later in life, has been linked to decreasing lung function.[12]

While the prevalence of asthma increased among all racial groups in children and adults, the biggest disparity is found among Black children with a difference in prevalence rate of approximately 8% compared to the next nearest racial group. This increase in asthma prevalence for all racial groups follows the trend seen nationally over the past couple years. However, the trend does not explain the increase in the prevalence gap among racial groups. The gap might be explained by the installment of the Affordable Care Act (ACA) in 2010, which allowed for increased access to the healthcare system. Additionally, the ACA might explain the increase in prevalence of asthma among all groups. Between 2010 and 2018 the Kaiser Family Foundation found a decrease of uninsured rates among all racial populations, most notably a drop from 32.6% to 19.0% among Hispanics, and smaller but still significant drops from 19.9% to 11.5% among Blacks, and 13.1% to 7.5% among Whites.[14] This is especially true for Hispanic populations as their insurance rate drastically increased since the adoption of the ACA. Increased access may lead to a higher rate of diagnosis, which then leads to an increased prevalence of a disease reported by the BRFSS since their question asked if a physician had ever diagnosed them with asthma.

There was a significant difference in asthma prevalence among gender in both children and adult populations in 2011 and 2014. CDC data from 2018 showed that this difference in asthma prevalence among gender was still present. Previous research has elucidated the same findings, however mechanisms surrounding the disparity are still unclear. Fuseini et al summarized the findings of several studies surrounding sex hormones and their role in asthma, and while a link seems to be present it is unclear as to how the mechanism works.[15]

Air quality measured in $PM_{2.5}$ showed mostly weak to no correlations to the prevalence of asthma among adult or children, regardless of gender or race and ethnicity. Only when compared

with Hispanic adults in 2011 did air quality show a moderate correlation with asthma prevalence. In other studies air quality measured in $PM_{2.5}$ had direct effects on quality of life and asthma exacerbations, but not necessarily the prevalence. While air quality in those years did not correlate with prevalence, it may be because lung damage from these particles might take years to have effect and increase asthma prevalence. However, this would be hard to prove or test as there would be too many cofounding factors affecting asthma development and prevalence.

Conclusion

This project had several limitations, the first of which is a limited sample size especially in the child population of 2011. Minimal data was available on several racial groups from states on the prevalence of asthma in children. Second, the air quality data measured in $PM_{2.5}$ was averaged for each state blurring areas that might have had higher concentrations of particulate matter with those of lower particulate matter. Lastly, the asthma prevalence data collected arose from a self-reported survey. This allows for errors in reporting, as some people might report they had been diagnosed by a physician with asthma when they had not or data might have been under-reported. Additionally, this was a randomized phone survey, which under-reports those who do not have access to a phone or have undiagnosed asthma.

Future directions include conducting this study again but with more up-to-date data as the sample used was from 2014. Additionally, obtaining a larger sample size would increase the validity of this experiment. Other directions taken could include correlating asthma prevalence and air quality with zip code and its related socioeconomic demographics. Lastly, how the ACA has affected asthma prevalence and disparities is another point of potential research. This may give further insight and context to the observed disparities among groups.

Asthma prevalence and disparities have been present since the early 2000s and have continued to be present through 2011 and 2014. This project has reaffirmed the prevalence of asthma disparities and shed light on the possibility that asthma disparities might be larger than when initially discovered. This may be due to the implantation of the Affordable Care Act in 2010, which increased access to health care substantially among minority populations. Increasing prevalence in asthma in both children and adults is concerning because of the associated risk of other developing other diseases.

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