PREVALENCE OF ASTHMA ACCORDING TO WILDFIRES IN CALIFORNIA: A CROSS-SECTIONAL SECONDARY DATA STUDY

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ABSTRACT

This cross-sectional study aimed to test the associated risk factors between asthma and wildfires in all 58 counties of the state of California, USA using secondary data from the years 2013 to 2020. The dependent variable was respiratory disease measured by % of the population who have asthma during the sampled period. The main exposure was the number of wildfires measured as fire statistics at the county level according to The California Department of Forestry and Fire Protection. Risk factors associated with asthma were also tested: PM 2.5, Preventable Hospitalizations, Adult Obesity, Adult Smokers, Lung and Bronchus Cancer, Sex [Male/Female], Age [<5 years, <18 years, 65< years], and Ethnicity [Asian, White, Black, and Hispanic]. The average prevalence of asthma and number of wildfires was 15.8% (10.7%-26.7%) and 5% (1%-33%) in the investigated counties. The Bivariate analysis showed a direct negative association: preventable hospitalization (p=0.006), average daily PM 2.5 (p=0.008), being Black (p=0.017), <5 years (p=0.020), <18 years (p=0.027), and 65< years(p=0.033). These variables remained associated with respiratory diseases after running them in the final regression model. Our results confirmed previous similar findings that support a possible relationship between respiratory disease and wildfires. Despite the limitations in a cross-sectional study, it emphasizes the demand for broader studies for finer clarification on the environmental impact of wildfires on related public health issues such as respiratory disease.

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INTRODUCTION

Respiratory disease affects hundreds of millions of people worldwide and is the cause of over four million premature deaths each year. Respiratory conditions such as asthma, chronic obstructive pulmonary disease, acute respiratory infections, tuberculosis, and lung cancer contribute to the global burden each year (Ferkol, 2014). While infectious diseases account for a large number of respiratory illnesses, air pollution is also a leading cause of respiratory illnesses. Globally in 2012, over 3.7 million deaths were due to air pollution **(**Nickerson, 2020**)**. In the U.K, 25.7 deaths per 100,000 were attributable to household ambient air pollution, mortality for men dropped from 151 to 89 (per 100,000 people), between the years 1985 and 2015 while women, their mortality increased slightly from 67 to 68 (per 100,000 people) (Salciccioli, 2018). This trend was seen throughout Europe, the decrease and slow increase in death can be attributed to public health initiatives and treatment protocols such as anti-smoking initiatives and earlier diagnosis of diseases (Salciccioli, 2018).

Air pollution is a severe environmental problem in the U.S. for example, from 1980 to 2014, mortality due to chronic respiratory diseases increased by 29.7% and in 2015 was the fifth cause of death in the U.S with nearly 6.7% of all deaths being from respiratory illnesses (Jiang, 2016; Dwyer-Lindgren, 2017). Chronic respiratory illnesses are also the eighth leading cause of health burden, costing an estimated $132 billion in personal health expenditures in 2013. The U.S counties located in central Appalachia have the highest mortality for chronic obstructive pulmonary disease and pneumoconiosis, while the southwest has the highest cases of interstitial lung disease (Dwyer-Lindgren, 2017). In the U.S, air pollution is responsible for between 90,000 and 360,000 deaths each year (Nickerson, 2020). The top

three air pollutants in the U.S are Nitrogen Oxide, Carbon Monoxide, and particulate matter; all three of these are emitted during a wildfire (Montrose, 2020).

Each year millions of acres of land are burned by wildfires in the U.S and around the world such as in Australia and in the Amazon forests of Brazil. In the last five years, wildfires in the U.S have increased by 100 more fires each year, this has led to more acres burning for longer and thus emitting more pollutants. No state has more wildfires than California with over 8,000 fires reported in 2019 as it exceeds the next state (Texas) by almost 2,000 fires. These fires typically burn for weeks or months on end causing numerous health effects in its wake. After just six days of being constantly exposed to smoke people develop higher rates of eye symptoms, dry cough, sneezing, sore throat, and wheezing. Among children with previously diagnosed asthma, asthma attacks increased by 63% (Kunzli, 2006). In California after a population has been exposed to a wildfire, there was an increase in primary care visits for a 12-week period (Lui, 2015). The longer the exposure to wildfire pollutants the higher the risk that anyone will be admitted to the hospital and the chance increases if there are pre-existing conditions such as COPD (Reid, 2016).

Along with having underlying conditions, there are several other factors that can have a direct effect on respiratory health such as BMI, smoking, occupational risks, gender, and ethnicity. Smoking is one of the most common risk factors as current smokers had higher odds of being affected by respiratory illness (Halldin, 2015). BMI can also affect respiratory health, those with a high BMI had a higher risk of being affected by a respiratory illness (Halldin, 2015). Fortunately, respiratory illnesses are often avoidable, and prevention costs only a fraction of what it costs to treat these diseases (Ferkol, 2014).

RESEARCH QUESTIONS AND HYPOTHESIS

The goal of this study is to investigate the trend of prevalence rates of respiratory disease according to the number of reported wildfires in California from 2013 to 2020. The study revolves around the following question:

RQ1: What is the trend of prevalence rates of Asthma according to the number of wildfires in California from 2013 to 2020?

It is theorized that there will be a higher rate of respiratory illness in counties that have higher numbers of wildfires than counties that have lower counts of wildfires.

H1: Counties will show lower rates of Asthma the less reports of wildfires.

H2: Counties will show higher rates of Asthma the higher the reports of wildfires.

H3: (Null Hypothesis) The rates of Asthma in a county are not associated with the number of reported wildfires.

METHODOLOGY

This present observational analytical ecologic study tested potential associations between Asthma in California counties testing and the occurrence of wildfires. Our unity of analysis was the 58 counties in California and the period for the data collected ranged from 2013 to 2020. The outcome of this study was Asthma, which is defined as airflow-obstruction or restrictive-pattern, type asthma. Airflow obstruction includes diseases such as asthma and COPD, whereas restrictive-pattern includes diseases that involve the chest wall, respiratory muscles, pleura, or lung parenchyma (Marcus et al, 2015).

In our present study, the main exposure is the number of wildfires that have occurred from the most recent open-access available data from the years of 2013 up until 2020. The other independent variables were: preventable hospitalizations per 100,000 as it is both a quality and assessment measure for primary healthcare; the prevalence of adult smokers measured by the number of adult smokers divided by the total population in the county from 2017; the prevalence of obesity measured by the number of individuals with obesity divided by the total population in the county from 2016; the prevalence of lung and bronchus cancer per 100,000 [measured by the number of individuals with lung and cancer divided by the total population in the county from 2013-2017]. We also tested sex [male/female] and age categorized

as under five years of age, under 18 years of age, and 65 years or up for age. Ethnicity and race were categorized into four groups including Asian, White, Black, and Hispanic.

Data collection was performed using five separate online open data sources that we are able to provide the most recent data from 2013 to 2020 on the populations at the county level. Census.gov was used for population size in each of the counties in California regarding sex, age, and race/ethnicity. Census.gov is a reliable governmental data source that is responsible for producing data in the United States at national, state, county, and municipality levels. Another data source used was the County Health Rankings website that gave multiple sets of information for prevalence in the different counties related to Asthma in terms of the different internal health risk factors. Also, using the California Department of Health website was useful in getting data on asthma prevalence. To obtain the number of wildfires per county in California, the California Fire governmental data site provided the needed information. The CDC, another government public health organization, then provided some useful information for data collection for Lung and Bronchus Cancer Rate Per 100,000. Therefore, using a variety of data sources based on the risk factors of Asthma is going to allow the investigation to continue with running descriptive analysis.

A descriptive analysis was conducted to obtain the results of the Chi-Square and Pearson correlation among the outcome and the exploratory variables. Then Pearson's correlation will measure the strength of the association between the values. There will also be a regression analysis test run after collecting the factors that prove most significant to the main factor, asthma prevalence. The statistical program that was used to analyze the data and perform the test was SPSS.

RESULTS

Our results showed that of the total number of counties in California (N=58), 52 had reported wildfires during the sample period of 2013 to 2020 (Table 1). The average number of reported wildfires in these counties was to be 5 in the investigated period. Then, 56 counties reported lung and bronchus cancer rates per 100,000 with an average of 1501.8 per 100,000. The descriptive statistics also resulted in the average percentage of asthma prevalence in the counties as 15.8 percent. The remaining average variables produced from the descriptive statistics for the total population in each of the counties were: average daily pm 2.5 at 10.1 percent; preventable hospitalization rate per 100,000 at 3,411.9; adult smokers 12.1 percent; adult obesity at 27.44 percent; female sex at 49.5 percent; male sex at 50.4 percent; age under 5 years at 5.7 percent; age under 18 years at 21.8 percent; age 65 years and up at 18.4 percent; being Asian at 8.5 percent; being White at 80.5 percent; being Black at 3.5 percent; being Hispanic at 31.3 percent.

Table 1. Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Total Population (census.gov)	58	1129.00	10039107.00	691245.2241	1467931.960
Average Daily PM2.5 (countyhealthrankings.org)	58	5.60	19.70	10.1362	2.90533
Preventable Hospitalization Rate Per 100,000 (countyhealthrankings.org)	58	2012.00	5716.00	3411.9828	855.43736
Number of Wildfires (fire.ca.gov)	52	1.00	33.00	5.0000	5.27294
Percentage of Adult Smokers (countyhealthrankings.org)	58	8.00	15.00	12.1034	1.66264
Percentage of Adult Obesity	58	17.00	41.00	27.4483	5.68831

(countyhealthrankings.org)					
Asthma Prevalence (cdh.org)	58	10.70	26.70	15.8672	3.37527
Lung and Bronchus Cancer Rate Per 100,000 (cdc.gov)	56	20.00	18307.00	1501.8036	2794.85969
Female Percentage (census.gov)	58	37.80	51.80	49.5069	2.12247
Male Percentage (census.gov)	58	48.20	62.20	50.4931	2.12247
Age Under 5 Years % (census.gov)	58	4.10	8.00	5.7655	1.12008
Age Under 18 Years % (census.gov)	58	13.40	30.50	21.8621	4.08909
Age 65 Year and Up % (census.gov)	58	10.50	32.00	18.4603	5.70189
Asian (census.gov)	58	.90	60.60	8.5759	10.96520
White (census.gov)	58	49.30	93.30	80.5810	10.81204
Black (census.gov)	58	.40	14.80	3.5948	3.18557
Hispanic (census.gov)	58	7.40	85.00	31.3862	18.23692
Valid N (listwise)	52				

The bivariate analyses according to Pearson correlation showed significant results with six variables associated with asthma prevalence (Table 2). Sex (percentage of male and female) was not associated with the outcome (r=.872, p=.887), contrary to preventable hospitalization rate per 100,000 (r=.455, p=.007) as most significant. The remaining significant variables from the bivariate analysis were: average daily pm 2.5 (r=.286, p=.009); being Black (r=.013, p=.018); age under 5 years (r=.607, p=.022); age under 18 years (r=.848, p=.029); age 65 years and up (r=.243, p=.035).

Table 2. Bivariate analyses according to Pearson correlation and respective significance.

County Risk Factors	Pearson Correlation	Significance
Preventable Hospitalization Rate per 100,000	.455	.007***
Average Daily PM 2.5	.286	.009***
Black	.013	.018***
Age Under 5 Years Percentage	.607	.022***
Age Under 18 Years Percentage	.848	.029***
Age 65 Years and Up Percentage	.243	.035***
Percentage of Adult Smokers	.036	.087

Hispanic	.229	.263
Lung and Bronchus Cancer Rate per 100,000	.157	.291
Percentage of Adult Obesity	.166	.383
Number of Wildfires	.008	.392
White	.066	.393
Asian	.000	.724
Female percentage	.872	.887
Male percentage	.872	.887

Regression Analysis

Our final model showed that preventable hospitalization rate per 100,000 (p=.006), average daily PM 2.5 (p=.008), being Black (p=.017), under five years (p=.020), under 18 years (p= .027), and 65 years and up (p= .033) were associated with Asthma.

Table 3. Final model according to regression analysis

Final Model	R	R^2 Cumulative	R^2 Change	F Change	Sig. F Change
Preventable Hospitalization Rate per 100,000	.354	.125	.110	8.036	.006
Average Daily PM 2.5	.345	.119	.103	7.553	.008
Black	.314	.098	.082	6.110	.017
Age Under 5 Years Percentage	.304	.093	.076	5.715	.020
Age Under 18 Years Percentage	.290	.084	.068	5.137	.027
Age 65 Years and Up Percentage	.280	.078	.062	4.757	.033

DISCUSSION

Our results did not find any link between asthma prevalence and the number of wildfires in the California counties in the investigated period. Other investigations similar to this one were based on the geographic location of respondents. In one study with the San Diego wildfires in 2007, there were 1,802 respondents sampled, most were 35–64 years old (65.9%), White (65.5%), and most (82.5%) lived more than 1 mile away from the fires (Sugerman et al., 2012). The data collected from the San Diego investigation implies that there is a large percentage of people who were within the range of the smoky air and the high risk of it affecting their respiratory health. As mentioned in Sugerman et al. (2021), in the

study, there were less than 10% of the respondents followed specific recommendations to protect their health. Comparing the sample from San Diego is only one county in California based on their wildfire encounters wherein future studies there could be more research done in individual parts of the counties to identify the hotspots of the affected communities. Another similar study was on southern Californian wildfires and concluded of PM 2.5 leads to increased respiratory hospital admissions like asthma which suggested that better preventive measures are required to reduce morbidity among vulnerable populations (Delfino et al., 2009). This study focused on the effects of particulate matter (PM 2.5) that wildfires can produce more of in air quality that may ultimately affect respiratory health, especially asthma. Between the southern California study and the present study is that our results indicated the being significant for the association of PM2.5 being associated with asthma.

Our findings were that the Pearson correlations for preventable hospitalization rate per 100,000 were the most significant, suggesting the health issue of asthma prevalence in California counties has a significant amount of hospital stays for respiratory disease conditions per 100,00 healthcare employees. The demographic factors that were associated with asthma prevalence such as age and race which were Black, age under 5 years, age under 18 years, and age 65 years and up. Therefore, individuals within those age range and are racially categorized as Black has a higher chance of being at risk of or developing asthma conditions. The association between average daily pm 2.5 and asthma as significant could be related to how wildfires produce more pm 2.5 when they are active, which endangers those with conditions like asthma for worsening breathing problems. One similar study focused on asthma prevalence among African American children in Los Angeles with the impact of ambient air pollution and found that several measures of disease exacerbation were associated with particulate matter in the quality of air (Ostro et al., 2001). Although the Los Angeles study was not conducting the investigation based on wildfires and their association with asthma, the particulate matter having significance with asthma is similar to our results. The goal of this study was to see if there was an association between the number of wildfires in California counties and respiratory diseases with asthma being the focus. Even with the results confirming the null hypothesis for there not being a link, the study still assisted in providing data further for investigations in other locations with wildfires and looking at other risk factors that wildfires may impact health.

The findings of this present study must be seen in the light of some limitations. The first limitation refers to the ecologic cross-sectional design because it measures prevalence as the data reflects the determinants of survival. The data could not exactly manifest when the disease occurred and if it were during a wildfire, the data source only provided the prevalence rate for the year. However, this limitation on the amount of data that we secured can also be a strength. The limitation refers to the use of secondary data as cases with developing conditions not yet diagnosed with asthma were not counted. As a result of the limited data set, the study was able to focus on a certain respiratory illness and gain more of an in-depth understanding of the certain respiratory illness. The cross-sectional study is not suitable for highly fatal respiratory diseases as our data collection referred to a more common outcome of asthma. Another limitation of this study could be the geographical constraints, we chose to focus only on the California wildfires as the sample can not be representative of other locations. However, wildfires occur all over the country and the world, therefore in the future to gain a better grasp on this information it would be interesting to look at how the geographical location of a wildfire affects respiratory health.

Our results can be used to further the field of public health through the lens of preparation for promoting respiratory health protection during the wildfires. Despite the fact the confirmation of the null hypothesis that there was no link between asthma prevalence and the number of reported wildfires in the California counties, the data can still be used to further public health programs that aim to protect against the harmful effects of wildfires. This study can also be a springboard for future studies as it compiles and analyzes a large amount of data on the different risk factors associated with respiratory diseases like asthma. Thus, one of the strengths of this study was the ability to identify the common risk factors of respiratory disease as it was also quick and easy to carry out the study with no cost expense. Also, another strength of this study was using initial research tools such as SPSS to discover what was most significantly associated with asthma prevalence in California where wildfires occur every year. Overall,

our significant results produced through the test runs may contribute to future public health studies in protecting and promoting respiratory health in areas that have high numbers of wildfires yearly.

CONCLUSION

This present investigation showed how the different risk factors of respiratory disease were collected between 2013 and 2020 based on geographic location in the 58 counties of California. Our research question was to identify the trend of prevalence rates of respiratory diseases, such as asthma, according to the number of California wildfires in those counties during the sample period. Comparing previous research studies with ours has shown that there is a correlation between respiratory disease and wildfire smoke exposure. However, in this present study, the data run tests that were performed led our study to accept the null hypothesis: the rates of respiratory disease in a county are not associated with the number of wildfires**.** There were some limitations as the research was affected by different outside variables that may have influenced respiratory health besides the impact wildfires to have on individuals. Yet there were also some strengths to the study design to have quick and to no expense research results produced. Although the results did not show the significance of the number of wildfires with asthma prevalence, other risk factors did which can be used for future research. For future studies, there should be more investigations on air quality (PM 2.5) on other respiratory diseases besides asthma and how it may affect certain demographics in a population such as African Americans.

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