Exploring Air Quality, Race, and Asthma in Californian Residents

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Abstract

Objective: Air pollution is the most significant environmental cause of disease and premature death; it is estimated to be responsible for approximately 6.5 million deaths worldwide and a wide range of diseases (National Institute of Environmental Health Sciences, 2022). This research considers air pollution in relation to asthma and exposure compared with existing literature. This study was conducted to understand the epidemiology and etiology of asthma disparities in children and air pollution across California and to highlight existing literature and policies to aid in addressing inequalities.

Methods: Data sets from the National Survey of Children's Health and CalEnviroScreen 4.0 were analyzed to determine if there is an association between a child's race/ethnicity or income (as measured by income being sufficient to afford essentials) and developing asthma. The study also endeavored to determine if there was a significant association between air quality and socioeconomic status (SES) across census tracts within California and if San Bernardino County has varying levels of asthma associated with air pollution based on census tract.

Summary: This study revealed a significant relationship between self-reported asthma rates and income categories, as well as a significant relationship between socioeconomic status and exposure to air pollution across California census tracts. African American children whose parents reported an inability to afford essentials based on their current income were the most likely to develop asthma. Lower-income individuals were more exposed to air pollution across California census tracts, and there is no correlation between pollution burden and asthma rates across census tracts within San Bernardino County.

Keywords: asthma disparities; air pollution; California; socioeconomic status

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I would like to praise God for all his goodness! After struggling with health issues over the years, I am very grateful for the opportunity of the ability to pursue a further education. From one day to today, I could not have done it without all the help along the way from my family, friends, and educators.

Table of Contents

Introduction

Overview of the Literature

Air pollution is the most significant environmental cause of disease and premature death; it is estimated to be responsible for approximately 6.5 million deaths worldwide and a wide range of diseases (National Institute of Environmental Health Sciences, 2022). This research considers air pollution and its lingering effects on human health, focusing on asthma, compared with existing literature. Studies conducted in an urbanized population by Tiotu and Colleagues (2010) demonstrated an association between asthma morbidity and air pollution, with children disproportionately affected by the adverse health effects compared to adults. With increased susceptibility to pollutants and increased pollutant exposure, there is a linkage between reduced lung function and increased asthma-related healthcare utilization among children. Understanding the disproportionate impact of air pollution and the burden of asthma morbidity across communities and populations is necessary to inform improvements to help people live healthier and better lives (American Lung Association, 2020).

Air Pollution

Air pollution is a mixture of complex chemical compounds from different sources such as combustion, industrial, agricultural, or natural sources. These are made of particular matter (PM), ozone, carbon monoxide (CO), sulfur and nitrogen oxides, methane, volatile organic compounds, and metals. (American Lung Association, 2020). Traffic-related air pollution (TRAP) encompasses numerous gasses (nitrogen dioxide [NO_2], sulfur dioxide [SO_2], benzene), and particulate matter associated with fossil fuel combustion. Nitrogen dioxide (NO_2) is commonly recognized as an important indoor and outdoor pollutant associated with the development of wheezing and lower forced expiratory volume in 1 second of forced expiratory volume (FEV_1). Nitrogen dioxide (NO_2) is generated from automobiles and gas heaters (Harris, 2019).

Most outdoor air pollution is well beyond the control of individuals and demands actions from local and national level policymakers working in sectors like transport, energy, waste management, urban planning, and agriculture can reduce the output of air pollution (World Health Organization, 2018). By reducing air pollution, the burden of diseases from stroke, heart disease, cognitive diseases, lung cancer, and both chronic and acute respiratory illness will be significantly reduced.

San Bernardino County comprises a diverse collection of communities in the Inland Empire of Southern California. Southern California is a region significantly impacted by traffic-related air pollution (TRAP). It ranks as the worst county in the entire nation for Ozone Pollution and the 9th worst polluted county for particulate matter pollution (American Lung Association, 2022). According to the State of the Air 2022 report, San Bernardino County is one of fourteen counties nationwide that received a failing grade for each of the three measures of pollution, including ozone, daily particulate matter ranking, and annual particulate matter ranking (American Lung Association, 2022). According to the Environmental Protection Agency (2020), San Bernardino County's air quality is moderate when measured by the Air Quality Index. However, based on the five index categories ranging from good to very unhealthy, extremes were more common in 2020 with more good days and more unhealthy days, especially compared to neighboring California counties and peer regions outside of California. This determination was based on the variation in the frequency of days each region experiences from regional comparison data from 2019 to 2020.

According to the American Lung Association (2020), community health studies point to less apparent but concerning effects of year-round exposure to ozone. Researchers followed 500 Yale University students and determined that living in a region with high levels of ozone and related co-pollutants for only 4 years was associated with diminished lung function and frequent reports of respiratory symptoms. Determinants of abnormal patterns of FEV_1 growth and decline are multi-faceted, and the identification of factors associated with the timing of a decline from the maximal level requires longitudinal data, which are sparse, especially for those with asthma.

According to Burbank & Peden (2019), ethnicity, socioeconomic status, and the presence of certain gene polymorphisms may impact susceptibility to the adverse health effects of air pollution. Environmental exposures to indoor and outdoor pollutants may also influence asthma severity and control. In their research, it was found that improved air quality standards were associated with fewer asthma outcomes. This is vital information because this means children in more polluted areas are at higher risk of developing asthma.

Cognitive Decline

Air pollution and cognitive decline are growing global issues, and plausible lineage has been found by Budson (2020) between exposures to specific air pollutants and a heightened risk for dementia as well as other non-communicable diseases. The risk for cognitive decline increases with age, but exposure to air pollution, especially fine particulate matter, is a potential risk factor. Evidence suggests that greater exposure to air pollution is believed to increase the risk of insulin resistance, inflammation, stroke, hypertension, raised lipids, enhanced propensity towards coagulation, atherosclerosis, and oxidative stress, all conditions that raise the risk of cognitive decline (Peters et. al., 2019).

Research conducted in China suggested that long-term exposure to air pollution may cause cognitive impairment, dementia, and Alzheimer's disease. Exposure to air pollution was also linked to poorer performances based on verbal and math tests. The results were more pronounced for older individuals, those less educated, and men. If air pollution does not kill outright, it has lingering effects that impair memory and cause cognitive decline such as dementia and Alzheimer’s disease. (Budson, 2020).

Racial and Ethnicity Disparities

It is vital to determine those most at risk for asthma and impaired lung function associated with pollution and prioritize prevention efforts for high-risk populations. The CDC (2015) estimates that approximately 40% of children with asthma do not have their disease under control. According to research by Ebell et. al. (2019), it was found that the strongest independent predictor for children developing asthma was being African American; the likelihood also increases when parents made less than $75,000 a year. In addition, African American children are 2-5 times more likely to experience asthma-related hospitalizations and emergency room visits than children in other ethnic groups. (Ebell et. al., 2019).

Children's Health

According to the American Lung Association (2020), studies reveal that children face heightened risks from air pollution compared to other age groups. Children are at a heightened risk because their lungs are growing, and their lifestyles are different since they are outside longer and more active, thus breathing in greater amounts of air. Additionally, children have more respiratory infections than adults, which seems to increase their susceptibility to air pollution. Childhood impairment of lung functionality and being male were the most outstanding predictors of abnormal longitudinal patterns of lung-function growth and decline. Children with chronic asthma and reduced lung function growth are at an increased risk for fixed airflow obstruction and potential COPD in early adulthood. (McGeachie, et. al., 2016).

Eighty percent of children's lung's tiny air sacs develop after birth. Those sacs, called alveoli, occur where the life-sustaining transfer of oxygen to the blood. The child's lungs and alveoli are more vulnerable to harm since they are not fully developed until adulthood. The body's defenses that help adults fight off infections are still developing in a child's body.

Research from Usemenn et. al. (2019) found a linkage between exposure to moderate air pollution from before birth to early childhood and lung function at school-age on a population level in healthy children. An even stronger association was found between air pollution and reduced forced expiratory volume (FEV) values in a subgroup exposed to the highest pollution levels of over 20 $\mu g/m^3$ NO_2. It is significant that in infants, dose-dependent effects are observed even at NO_2values below the World Health Organization (WHO) guideline limits of 40 μg/m^3 to determine if functional growth impairment may already be present. If infants are currently exposed to low-level air pollution between pregnancy and the first two years of life, the most critical stages of lung growth and vulnerable lung development (Voynow & Auten, 2015).

A large study in California by the American Lung Association (2020) found that pregnant women who lived in areas with higher particle pollution levels were at an increased risk of preterm birth (Laurent et al., 2016). However, another study illustrated that there was a heightened risk for preterm birth even at low particle pollution levels. (Nachet. et. al., 2016). Further research by Nashman et. al., (2016) revealed that despite relatively low levels of exposure, a positive relationship was found between PM2.5 exposure during preconception, each trimester of pregnancy, and intrauterine inflammation (IUI) at birth. Findings suggest that IUI may be a determinant for assessing the early biological effect of PM2.5 exposure on a developing fetus, which may influence subsequent growth, development, and health outcomes.

In 2015, a study by Southern California Children's Health looked at the long-term effects of air pollution on children. Researchers tracked 1,759 children between ages 10 and 18 and found that children who grew up in higher polluted areas had an increased risk of reduced lung growth, thus lungs that may never recover to their total capacity. This average drop in lung function was similar to the effect of growing up in a home with parents who smoked (American Lung Association, 2020).

Gaps in Existing Literature

Further research is needed to investigate risk factors, the relative impact of exposure during young age, and its association with low-level pollution. This research can determine if impairment of lung function growth at even low concentrations will affect a large proportion of healthy children and could significantly impact public health in the future.

Purpose of the Study

This study aims to determine if racial-ethnic factors and income are good predictors of children developing asthma. With this information, there can be improvements to program effectiveness, determining who the vulnerable populations are, and all other future efforts.

Research Questions

1. Is there racial/ethnic difference in self-reported asthma among children?
2. Among children, is there a statistically significant relationship between self-reported asthma and income (as measured by income being sufficient to afford essentials)?
3. Is an association between socioeconomic status and exposure to air pollution across census tracts in California
4. Is there an association between pollution burden and asthma across census tracts within San Bernardino County?

Hypothesis

The research hypothesis for the first research question was that there would be a statistical significance in self-reported asthma amongst children across racial/ethnic groups. The null hypothesis for the first research question was that there is no statistical significance in self-reported asthma amongst children across racial/ethnic groups.

The research hypothesis for the second research question was that there is statistical significance between self-reported asthma and income category (as measured by income being sufficient to afford essentials) among children. The null hypothesis for the second research question was that there would not be a statistical significance in self-reported asthma in children and income category (as measured by income being sufficient to afford essentials).

The research hypothesis for the third research question was that there would be an association between socioeconomic status and exposure to air pollution across California census tracts. The null hypothesis for the third research question was that there would be no association between socioeconomic status and exposure to air pollution across California census tracts.

The research hypothesis for the fourth research question was that there would be an association between pollution burden and asthma across census tracts within San Bernardino County. The null hypothesis for the fourth research question was that there would be no association between pollution burden and asthma across census tracts within San Bernardino County.

Methods

Design

Data from the US Census Bureau's 2020 National Survey of Children's Health (NSCH) and CalEnviroScreen 4.0 (CES) were used to answer the four research questions. Specifically, data from the NSCH was utilized to investigate research questions one and two, while data from the CES 4.0 was utilized in the analysis for research questions three and four.

Procedures

A comprehensive review was conducted to find existing literature on SES, asthma in children, and air pollution using the CBU Health Sciences Database. Keywords and phrases used were "socioeconomic injustice and air pollution", "environmental justice and air pollution", "asthma and children", and "socioeconomic status and air pollution". These keywords yielded 734 published papers after excluding duplicates, partial text, and literature before 2017.

Data from the NSCH were utilized for this study. The dataset was collected from the Data Resource Center for Child & Adolescent Health from 2019-2020. A dataset request was made and granted by the Child and Adolescent Health Measurement Initiative (CAHMI). The data set included 72,210 completed surveys for 2019 and 2020 combined. Survey data was weighted to represent the population of non-institutionalized children 0-17 who lived in housing units. An SPSS file was uploaded directly from the website. A national sample of 240,000 addresses was initially selected for the 2020 NSCH. During data collection, a screener questionnaire was used to identify households with children and roster children in the household.

The screener questionnaire also included several questions to identify children with special health care needs. One child was randomly selected from each eligible household, and that child was the subject of a more detailed topical questionnaire. Responses to the screener and topical questionnaires were collected, processed, and published in the Screener Public Use and Topical Public Use files. (Child and Adolescent Health Measurement Initiative. (2021).

The 2020 NSCH data set originated from the US Census Bureau, surveys were administered to participants online and via mail. Randomly selected addresses from households across the United States were mailed instructions on how to access the online survey. After two reminder letters and postcard reminders to complete the survey, households who had not accessed the online survey were mailed a paper questionnaire. Both paper and online respondents were initially asked if one or more children ages 0-17 lived in the household. If yes, Respondents filled out an initial questionnaire regarding the age and sex of all children in the household. If not, the survey ended. One child from each family is randomly selected to be the subject of the main questionnaire. Respondents completed one of three versions of the survey, based on the selected child's age between 0-5, 6-11, and 12-17. Additional information collected on other children included race/ethnicity, household language, housing status, and the presence of special health care needs. Approximately 93,840 households were screened for age-eligible children in sampled addresses, and 51,107 children were reported on completed questionnaires. A total of 42,777 child-level topical questionnaires were completed, with 10,044 topical questionnaires completed (Child and Adolescent Health Measures Initiative, 2021).

The U.S. Census Bureau determines the federal poverty level each year. The poverty level is based on the household size and family members' age. If a person or family's total income before taxes is less than the poverty level, the person or family is considered in poverty. (U.S. Census Bureau, 2021).

Data from CES 4.0 was utilized for the study. CES 4.0 is from the Office of Environmental Health Hazard Assessment (OEHHA), an office within the California Environmental Protection Agency. CES 4.0 is a mapping tool that uses environmental, health, and socioeconomic information to identify communities in California that are most affected by pollution and where people are especially vulnerable to the effects of pollution. This information produces scores for every census tract in the state and ranks based on data available from state and federal government sources.

CES 4.0 uses the census tract as the unit of analysis; California has about 8,000 census tracts. These census tracts comprise multiple census blocks, ranging from the smallest geographic regions and unpopulated indicators of pollution burden and population characteristics with percentile scores for each indicator. The scores are mapped out to compare different communities. Areas with high scores experience a higher pollution burden than areas with lower scores. The data set was downloaded as an excel file and then converted to SPSS.

Participants

The participants sampled from the 2020 NSCH were randomly sampled from US Census Bureau Data Bureau and contacted by mail and an online invitation to complete a short questionnaire. The 2020 NSCH sampled approximately 240,000 addresses to participate in their survey. Of this population, 3,609 participants were used for this research study. This data was utilized to address research questions 1 and 2. (Child and Adolescent Health Measures Initiative, 2021). CES 4.0 participants are sampled from Government Operations Agency sponsors data.ca.gov, a statewide open data portal. The state collected public data through its routine business activities and made available at the census tract and zip code level. While 143 was the minimum sample size, all 369 census tracts in San Bernardino County were utilized exceeding the minimum sample size requirements. The CES 4.0 census tract level data was utilized to answer research questions 3 and 4. (U.S. Census Bureau, 2021).

Independent Variable and Dependent Variable

The independent variable for the first research question was race/ethnicity. Response options were numerically coded as the following: 1 = “Hispanic", 2 = "White, non-Hispanic", 3 = "Black, non-Hispanic", 4 = "Asian, non-Hispanic", 5 = "Other/multi-racial, non-Hispanic", 99 = "Missing to Hispanic or race/ethnicity or Both". The dependent variable for the first and second research questions asks, “Does the child have the condition”. Responses were coded as the following: 1 = "Does not have condition", 2 = "Ever told, but does not currently have condition", 3 = "Currently has condition". The dependent variable for the first and second research question was, ‘Has a doctor or healthcare provider ever said the child has asthma?”. Responses were coded as the following: 1 = “Yes”, 2 = “No”. The independent variable for the second research question asks, "How often has it been hard to get by on your family's income - hard to cover basics like food or housing since the child was born?". Responses were coded as 1= "Very often or somewhat often" 2 = "Never or rarely". The dependent variable for the second research question asks, “Has a doctor or other health care provider EVER told you that this child has Asthma?”. Responses are coded as 1 = “Yes”, 2 = “No”.

The independent variable for the third research question was the percent of the population living below two times the federal poverty level. The dependent variables for the third and fourth research questions are asthma rates measured by emergency department visits for the condition.

The independent variable for the fourth research question is pollution burden. This is calculated from the averages of percentiles from the 7 pollution burden indicators combined. The pollution burden variable is scaled with a range of 0.1-100 (used to calculate the CES 4.0 score). The variables included in this total score consist of 7 exposures: ozone PM2.5 concentrations, diesel PM emissions, drinking water contaminants, children’s lead risk from housing, pesticide use, toxic releases from facilities, and traffic density.

Data Analysis

A kruskall wallis analysis was used for question 1 to determine if there was a statistically significant difference in self-reported asthma in children across race ethnicity groups. A chi-square test of independence was used for question 2 to analyze cross-tabulations of the survey response data to reveal the frequency and percentage of children with asthma between those who do and do not self-report, finding it hard to cover basic essentials on their current income. The chi-square test of independence was also utilized to evaluate a potential bivariate association between socioeconomic status, as measured by the ability to afford essentials, and self-reported asthma in children. Due to the high volume of participants in the NSCH data, only 5% of the sample was used. Pearson's correlation coefficient was used for questions 3 and 4 to measure the statistical relationship between pollution, a continuous variable to give information about the magnitude of the association and the direction of the relationship.

Results

Major Findings

For question 1, it was hypothesized that there is a statistically significant difference in self-reported asthma rates across racial/ethnic status categories. A kruskall wallis analysis was performed to compare the frequency of asthma diagnosis across all races/ethnicities. The kruskal wallis H test revealed statistically significant differences in asthma across race/ethnicities ($H(5) = 31.928, p < .001$). Self-reported asthma rates were significantly different across race/ethnicity categories. A Dunn's test post-hoc analysis was completed to perform pairwise comparisons and further investigate differences in self-reported asthma across races/ethnicities. Black or African American children experienced a much higher rate of asthma compared to white children ($p < .001$) and Asian children ($p < .001$). Children of two or more races also experienced asthma at a higher rate than white children ($p = .016$) and Asian children ($p = .011$). Specifically, Black children had the highest rate of self-reported asthma diagnosis at 19.4%, followed by American Indian/Alaskan Native (15.2%), Two or more races (14.5%), White (10.0%), Asian (7.2%), and Native Hawaiian/Islander (3.7%). The small sample size for American Indian/Alaskan Native (n = 33) limited the statistical stability of pairwise comparisons involving that group.

For question 2, it was hypothesized that there is a relationship between self-reported asthma rates and income categories. A Chi-Square Test of Independence was performed to compare the frequency of self-reported asthma in children across income categories. The calculations revealed a statistically significant relationship between self-reported asthma and a lack of ability to afford basic needs based on current income (X^2 *(1) = 6.106, p < .013*). Children in families who had a more difficult time affording basic needs reported a higher occurrence of asthma (14.8%) compared to those who rarely or never struggled to meet basic needs (10.6%) (*OR = 1.409*). Self-reported asthma rates were significantly associated with the income category, with those having a more difficult time affording basic needs being 1.4 times more likely to have asthma.

For question three, it was hypothesized that there is a relationship between socioeconomic status and exposure to air pollution across census tracts within California. CES 4.0. A Pearson's correlation was performed to compare the frequency between socioeconomic status and exposure to air pollution across California census tracts. Calculations reveal a significant association with (*r(7958366) = .375494, p <.001*) when this analysis was performed on all census tracts in California (n = 7960). However, to rule out the possibility of a Type I error, the analysis was also performed on a sampling of census tracts (n = 784) with nearly identical results (*r*(782) = .379, *p <.001*). Socioeconomic status was significantly associated with exposure to air pollution across census tracts in California. Socioeconomic status and exposure to air pollution amongst California census tracts are correlated with each other.

For question four, it was hypothesized that there was an association between pollution burden and asthma across census tracts within San Bernardino County. CES 4.0. A Pearson’s correlation was performed to compare the frequency between pollution burden and asthma across census tracts within San Bernardino County; the Pollution Burden Score is not significant, (*r*(366) = -.085, *p* =.105). Pollution burden and asthma are not significantly associated across census tracts in San Bernardino County. Pollution burden and asthma rates appear to be independent of one another.

Discussion

Summary of Major Findings

The results of research question one indicate a statistically significant relationship between self-reported asthma rates and race/ethnicity ($p = .001$). The strongest independent predictor for children developing asthma was based on race/ethnicity, more specifically, being African American. These results are congruent to Ebell et al. (2019), which states that African American children are 2-5 times more likely to experience asthma-related hospitalizations and emergency room visits than other ethnic groups.

The results of research question two indicate a statistically significant relationship between self-reported asthma rates and income categories ($p = .013$). These results are congruent to research by Ebell et al. (2019) that found a statistically significant relationship between asthma rates and income categories. The likelihood of developing asthma increases when parents make less than $75,000 a year. Further research by Kozrysky et al. (2010) examined 2868 children in Western Australia to determine if there was an association between changes in family socioeconomic status and childhood asthma. It was found that consistent exposure to a low-income environment from birth was associated with the developing persistent asthma. There was also a protective effect against asthma among those children whose families moved out of poverty (Kozrysky et al., 2010).

The results of research question three indicate an association between socioeconomic status and exposure to air pollution across census tracts in California ($p = .001$). This is congruent with Hajat et al. (2015) that current research and environmental inequality literature from North America, New Zealand, Asia, and Africa show that lower SES communities have increased concentrations of criteria air pollutants compared to other SES groups. (Hajat et. al., 2015). Research by Kozyrskyl et al. (2010) found that chronic exposure to a low-income environment beginning at birth was associated with the development of persistent asthma. Additionally, there was a protective factor against asthma amongst children whose families had moved up from poverty.

The results of research question four indicate there is no association between pollution burden and asthma across census tracts within San Bernardino County ($p = .105$). Based on the census tract, there is no statistically significant association between pollution and asthma rates in San Bernardino County. The student researcher believed significant results would follow based on the American Lung Association (2022) State of Air report. Data reveals that San Bernardino County is the most polluted county in America, with the highest ozone and 9th highest PM ranking in the nation. (American Lung Association, 2022).

One possible explanation for no association between socioeconomic status and asthma rates captured at the census tract level within San Bernardino County, is a lack of health literacy. Lower levels of health literacy could increase the likelihood that individuals may be less likely to recognize signs of asthma and therefore not seek treatment for the condition. Based on CES 4.0 data, the correlation between education levels and asthma is highly significant, ($p<.001, r = .407$), with individuals of a lower education level being more likely to be asthmatic. Based on data from San Bernardino County (2022), the proportion of high school graduates within San Bernardino

County’s general population rose from 78% to 81% between 2010 and 2019 for residents over age 25. However, at 81%, San Bernardino County falls below state (84%) and national averages (89%) for residents over the age of 25. Between 2010 and 2019, the proportion of San Bernardino County residents over the age of 25 with a bachelor’s degree or higher rose from 19% to 23%. Even at 23%, San Bernardino County is still below the state (35%) and nation (33%) for college graduates. (San Bernardino County, 2022).

Public Health Implications

This study understands the need to implement programs and policy changes to address the burden of air pollution in lower socioeconomic areas. These efforts can enhance environmental quality and health equity through health education and health advocacy in disadvantaged communities. CES 4.0 is a powerful data tool that addresses health inequity and environmental injustice. Programs must continuously improve the protection of public health and the environment, and programs and tools that support work that can help decision-makers address inequality. Government agencies and private organizations alike should use CES 4.0 to develop or further expand innovative ways to address pollution and similar public health concerns. (California Open Data Portal, 2021).

A study was conducted by Jhun et al. (2017) to reduce particulate pollutant exposures to examine the role of high-efficiency particulate air (HEPA) cleaners in elementary school classrooms. The intended outcome was to reduce indoor particulate pollutants to improve asthma morbidity outcomes for asthmatic children.

It was found that classroom-based HEPA cleaners were positively correlated with a significant reduction of fine particulate matter (PM2.5) and black carbon (BC). The intervention group had greater improvement in peak expiratory flow (PEF) compared to the control group (Jhun et al., 2017).

Properly addressing inequalities in pollution burden and asthma rates can enhance environmental quality and health equity through health education and health advocacy. Leaders can address environmental health disparities by meeting the healthcare needs of those most impacted. Providing more jobs to work indoors versus outside and better-constructed housing with climate control and air filtration. With program funding, multifaceted approaches to target home, school, and clinician-based interventions can be implemented to reduce allergens or pollutant exposure, educational and empowerment support for patients, and decision support tools and resources for medical providers. (Louisias & Phipatanakul, 2017). The material will include educating participants on the health effects of air pollution, communicating with local officials to reduce air pollution, and advocating for environmental justice through existing organizations or grassroots efforts.

According to the American Public Health Association (2017), recommendations include increasing EPA funding for ambient and community-scale air toxicity programs with an increased focus on environmental justice, developing, validating, and advancing monitoring and data analysis technologies. There is a dire need for government efforts to increase funding and support for the EPA to supplement recent budget cuts and provide funding for innovation and research.

Implementing and enforcing the Clean Air Act and the national air ambient air quality program to utilize the maximum achievable control technology program for air toxins and urban pollution initiatives are behind schedule or not being addressed due to budget cuts. (American Public Health Association, 2017)

Study Limitations

Limitations that should be noted are that some participants did not complete or finish the surveys. A small portion of surveys had missing data. Also, one may misinterpret data looking at Asian Americans, and Pacific Islanders as this group is only 6% of the American population. Studies often leave out American territories and poorer Asians like Cambodians, Laotian, Hmong, and Vietnamese in research. Entire groups of people get left out of research, and society fails to meet the needs of this subpopulation. Albeit, existing literature and data from CES 4.0 and NSCH reveals that impoverished individuals are most impacted.

Self-reporting, used for NSCH data collection, is subject to bias and limitation. Subjects may lack honesty, choosing more pleasant answers and falsely stating that their child has no chronic conditions. Participants may also be unable to properly assess their children because of a lack of health literacy (i.e., not recognizing signs of asthma and/or not regularly seeing a doctor). If a question asks, “does this child have asthma, 1= yes or 2= no”, the child may not have been formally diagnosed by a doctor because they have not been to the emergency department because of non-emergency symptoms and answer no.

CES 4.0 data is based on census tract data; a limitation that could occur is survey fatigue. Census surveys tend to be longer than typical surveys, and respondents may rush to finish, making the results ineffective. Also, individuals who complete the survey may not always represent the intended population. Lastly, the census method has a large volume of data which increases the chance of statistical errors such as data saturation.

Another limitation of the study included the limited variables and information contained in each data set analyzed and the specific variables explored in this study. The Cal Enviro Screen 4.0 data utilized did not include specific geographic information or other environmental exposures. Specifically, this study did not consider the impact that individuals' proximity to railyards, ports, highways, and other known pollution centers have on childhood asthma. This study also did not explore the impact of other health behaviors and environmental factors, such as living in a household with a smoker having on asthma risk.

Conclusion

This research summarized that scientific findings and current literature supported the hypothesis that childhood asthma and exposure to air pollution disproportionately affect lower-income individuals. This study demonstrated a statistical significance between racial/ethnic status and childhood asthma and no association between air pollution exposure and asthma within San Bernardino. Hajat et al. (2016) recommends that environmental inequality research has implications for health effects analyses. Health researchers must understand if and how the individual and/or area-level socioeconomic status may confound, exacerbate, or mitigate the association between air pollution and health outcomes. Air pollution and SES can be highly variable from one location to the next, and researchers must be meticulous in consideration of representation within the context of health studies. (Hajat et. al., 2016). Conclusively, it is essential for collective efforts between scientists, healthcare workers, and government officials to successfully implement policy changes that will reduce air pollutant exposures and improve children's health. (Burback & Peden, 2018).

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