ENVIRONMENTAL JUSTICE AND CHILDREN: OUTDOOR ENVIRONMENTS FOR DIFFERENT RACIAL/ETHNIC YOUTH GROUPS IN PRINCE GEORGE'S COUNTY, MD

XU, YIKE
Cornell University, yx575@cornell.edu

KWEON, BYOUNG-SUK
University of Maryland, kweonb@umd.edu

ABSTRACT
Nearly one third of the world's 4 billion people living in urban areas are children. Studies show that urban outdoor environments play an essential role in the development of children's physical and mental health, and social relationships. However, environmental injustice affects accessibility to outdoor amenities between white and racial/ethnic minority communities. Household income level is also closely related to the outdoor environments of young people. This study investigated the issue of environmental injustice by exploring the connection among youth demographics, neighborhood socio-economic status, and outdoor environments such as green space accessibility, air quality, and proximity to environmental pollution.

We collected zip code level youth racial/ethnic demographics, socio-economic information, and environmental data in Prince George's County. Prince George's County was selected because it has a diverse demographic of children representing various racial and cultural backgrounds. In addition, it was designated as one of the four UNICEF Child-Friendly Cities Initiative. To analyze the data, we ran multiple linear regressions to reveal how children's racial/ethnic backgrounds and economic status link to the environmental indicators listed above. Our findings show that areas with a higher percentage of Hispanic children and lower median household income had a higher level of air and environmental pollution, and lower tree canopy coverage. These results suggest that Hispanic children and children from low-income families are most affected by environmental injustices related to pollution and tree cover. More investment in green infrastructure and outdoor facilities may be needed in these communities to support children with access to urban green spaces.

Keywords
Air Pollution, Environmental Pollution, Parks, Tree Canopy Coverage, Environmental Injustice

1 INTRODUCTION

1.1 Outdoor environment is important to children

Today, nearly one-third of the world's 4 billion people living in urban areas are children ("Growing Cities", n.d.). The increasing prevalence of children growing up in urban areas has prompted widespread attention to the influence of outdoor spaces on their development. Various studies have shown that the urban outdoor environment is an important setting for the healthy development of young people. For environmental benefits, research indicates that the quality of neighborhood parks is positively correlated with increased physical activity and reduced likelihood of obesity among residents (Bai et al., 2013). Similarly, another study has shown that improved access to parks and other recreational resources for children aged 9 to 10 have a decreased risk of being overweight and obese (Wolch et al., 2011). These findings suggest that there is a connection between the accessibility of outdoor spaces and the level of physical activity; consequently, it is influencing the physical health of young people. Furthermore, appropriate urban environments also contribute to children's health in many aspects. Owens's study (2017) illustrates that outdoor public spaces provide young people with opportunities to develop satisfying social relationships, find their role in society, establish a sense of belonging to a community, and then undertake social responsibility. Outdoor environments also allow children to manage free time that can be spent participating in recreational activities, which can help build character, encourage teamwork, and raise self-esteem in youth. Additionally, less visible public spaces function as prospective refuges for mental rejuvenation (Owens, 2017). Another study demonstrates that outdoor green spaces have positive effects on mental health through active participation and as an observable natural environment in a neighborhood (Nutsford et al., 2013). Children under the age of 18 living in greener environments exhibit enhanced resilience against stress, better emotional regulation, heightened attention and cognitive faculties, and an increased sense of well-being and longevity (Razani et al., 2015). Research has also indicated that children play more creatively and receive greater adult supervision in neighborhood outdoor spaces characterized by higher vegetation coverage (Taylor et al., 1998). In summary, the outdoor environment, especially green space, is an important setting for the healthy development of young individuals.

The extent of children's utilization of outdoor spaces is inherently linked to their accessibility and quality. Existing studies have concentrated on evaluating the accessibility and quality of outdoor spaces based on factors such as size, proximity to children's residences, vegetation coverage, availability of recreational facilities, and maintenance levels (Loukaitou-Sideris & Sideris, 2009). Studies show that children are most attracted to outdoor spaces featuring active low-cost and well-maintained recreation facilities (Loukaitou-Sideris & Sideris, 2009; Ries et al., 2008). It also suggests that children actively seek out trees for thermal comfort during hot weather (Lanza et al., 2021). Other critical attractions include higher green coverage, proximity to homes, park size (larger parks tended to attract more children), active recreation programs, maintenance quality (well-maintained parks tend to be more appealing to children), and safety measures (Dunton et al., 2014; Loukaitou-Sideris & Sideris, 2009). These attractions are important design considerations in landscape architecture and they have significant impact on planning and design in the profession.

1.2 Air and environmental pollution affect children's well-being and their opportunities to enjoy outdoor space

In addition to the quality and accessibility of outdoor space itself, air pollution and environmental degradation also affect children's outdoor activities. Most common air pollutants in the United States are criteria pollutants which include ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, and PM_{10} and PM_{2} (US EPA, 2014). Pollution not only curtails the time that young people can spend in nature but also has detrimental effects on their overall well-being (Bai et al., 2013). In recent years, the concentration of air pollutants like $PM_{2.5}$ is expected to increase because of changes in temperature, precipitation frequency, and air stagnation due to climate changes (Watts et al., 2015). Globally, air pollution is responsible for approximately seven million premature deaths each year, with a majority attributed to outdoor air pollution (WHO, 2022, December 19). While most of the deaths occur in developing countries, the issue of air pollution in developed countries should not be underestimated (Gardiner, 2021). Research conducted nationwide in the U.S. has revealed that even in places where the air met national standards, higher pollution levels were linked to higher death rates and higher hospitalizations for many ailments such as kidney failure (Gardiner, 2021). In addition, exposure to deteriorating lead-based paint is the most common source of lead exposure in children. For children under 6 years of age, the CDC defines elevated blood lead levels (EBLLs) as concentrations greater than or equal to 10 micrograms per deciliter (μg/dL). However, blood lead concentrations well below this standard may still be of concern for causing intellectual impairment(Carter-Pokras et al., 2007). These studies collectively indicate that even when air and environmental pollutants are below standard levels, they can still exert adverse effects on human health.

Moreover, research shows that children are more vulnerable to the detrimental effects of pollution than adults (Landrigan et al., 2018). Childhood exposure to air toxins has been linked to long-term health impacts, including ADHD (attention-deficit/ hyperactivity disorder), growth and development delays, heart disease, chronic obstructive pulmonary disease, and diabetes in adulthood. Additionally, early childhood exposure to pollution has been shown to affect educational attainment and test scores (Perera, 2017). For the impact of air pollution on the use of outdoor spaces, two studies conducted in Spain have indicated that young people aged 2-14 years living in areas with low levels of air pollution, particularly $PM_{2.5}$, are more likely to meet the 24-hour movement recommendations and less likely to have excess weight compared to those who live in areas with medium and high air pollution levels (López-Gil, Chen, et al., 2022; López-Gil, García-Hermoso, et al., 2022). The effects of environmental pollution on children are persistent and multifaceted.

1.3 Environmental injustice related to pollution and poverty, which further affects children's well-being

Environmental injustice worsens the situation for economically disadvantaged minority children. This is evident because these disadvantaged communities often reside in areas with lower-quality outdoor spaces and have less access to better urban green spaces. Moreover, these vulnerable groups are more prone to the harmful effects of environmental pollution.

Prince George's County's environmental inequality can be attributed to historical redlining practices. Despite being home to some of the nation's wealthiest African-American communities, the county's past reveals a less welcoming environment for its black residents. (Henry, 2019) Racial segregation in the county was closely linked to redlining practices that systematically directed African-American residents away from predominantly white neighborhoods. This segregation resulted in significant disparities in housing, education, and economic opportunities for African-American families (Rothstein, 2017). Consequently, redlining contributed to disparities in land ownership and wealth accumulation, as many African-American families in the county were unable to purchase homes or build generational wealth through property ownership, profoundly affecting the financial well-being of successive generations raised in these communities. (Rothstein, 2017) In terms of outdoor environments and urban tree canopy coverage, research has discovered the substantial influence of redlining policies on the distribution of trees and parks across the United States. After analyzing 37 U.S. cities including Baltimore, Locke's research (2021) revealed compelling evidence that tree canopy in communities predominantly inhabited by racial and ethnic minorities is approximately half that of predominantly white communities.

Child poverty frequently coincides with suboptimal outdoor living conditions. Children living in low-income neighborhoods are more likely to be exposed to hazardous environments and are most vulnerable to the adverse effects of toxic air pollutants (Evans, 2004; Perera, 2017). Previous investigations have discerned strong associations between childhood poverty, characterized by diminished household income, and heightened exposure to lead and ambient air pollution. Moreover, children in low-income neighborhoods also live closer to toxic waste dumps, and thus those children carry a heavier body burden of toxins (Evans, 2004). Regarding the physical environment, research indicates that tree coverage is significantly lower in neighborhoods with a higher proportion of African-Americans, residents with low-median-household-income, and renters ((Landry & Chakraborty, 2009). Another study unveiled disparities in children's access to parks, both in terms of proximity and quality, with notable associations between overall park quality and poverty (Chen et al., 2019). Children living in neighborhoods with higher poverty rates and rental rates exhibit a heightened potential need for parks; however, the availability of high-quality parks often does not align with this need. In such neighborhoods, parks are often more hazardous, lack essential amenities and aesthetic features, suffer from inadequate maintenance and cleanliness, and have more incidents of incivility. (Chen et al., 2019) The absence of park access can disappoint children of disadvantaged groups, which in turn affects their levels of physical activity and deprives them of the associated benefits (Chen et al., 2019; Evans, 2004). Furthermore, although many children (aged 0-17) from low-income families live within walking distance to parks, they often have access to fewer acres of parkland, let alone higher-quality parks (Rigolon, 2017).

The quality and availability of recreational facilities vary by neighborhood racial/ethnic composition in the U.S. (Rigolon, A., 2017). The author states that communities with higher percentages of African-American residents tend to have fewer physical activity settings. Census block groups with larger proportions of racial/ethnic minorities are less likely to have recreational facilities (Ries et al., 2008). Young individuals with limited access to facilities often resort to alternative play spaces such as streets and vacant lots, where they may risk injury from accidents. These safety concerns also hinder children's willingness to go outside (Ries et al., 2008). As for the impact of pollution, illnesses resulting from pollution are disproportionately prevalent among minority and marginalized populations. Children, in particular, are more vulnerable to the effects of pollution, especially during early infancy when even minimal exposure to contaminants can lead to illness, disability, and potentially life-threatening conditions throughout childhood and into adulthood (Landrigan et al., 2018). Landscape architecture plays an important role in designing or making policy decisions on how to create healthy, safe, equitable, and sustainable outdoor environments. It is important that all people regardless of their age, race, ethnicity, gender, and income have access to healthy outdoor environments.

2 RESEARCH OBJECTIVES

This study aims to investigate environmental injustice by exploring the connection among youth demographics, neighborhood socio-economic status, and children's outdoor living environment including green space accessibility, air quality, and proximity to environmental pollution. A secondary objective is to explore the environmental and social factors in Prince George's County (PG County) that are most associated with the environmental inequalities experienced by local children. Furthermore, while previous research has demonstrated an association between suboptimal outdoor environments and African-American neighborhoods in general, yet there is limited research regrading neighborhoods where children of diverse race and ethnic backgrounds reside. This paper endeavors to offer a comprehensive analysis by assessing the circumstances of children from various races and ethnicities.

3 METHODS

3.1 Study area

Prince George's County in Maryland State was selected as the study area. According to U.S. Census Bureau's American Community Survey (ACS) for the years 2016 to 2020, PG County is home to a population exceeding 900,000 individuals, with 22 percent of the residents falling within tha age group of 0-17 years old. This county encompasses a total of 63 zip codes (see Figure 1). Among these, 23 zip codes represent post-office areas without specific areas. Additionally, there are 4 zip code areas (20601, 20903, 20904, 20912) that primarily extend into neighboring counties, while the remaining 36 zip code areas are entirely contained in the PG County boundaries. The study used these 36 zip codes and included them as the data analysis units. It is worth noting that more than half of PG County consists of urban areas, with most of it falling within the Washington, DC—VA—MD (DVM) metropolitan region. Smaller portions of the county extend northward towards Baltimore and southward towards Waldorf. The urban areas have a dense transportation network and a high population. Conversely, rural areas are concentrated in the southeastern part of the county and a small portion of the northern part of the county (see Figure 2).

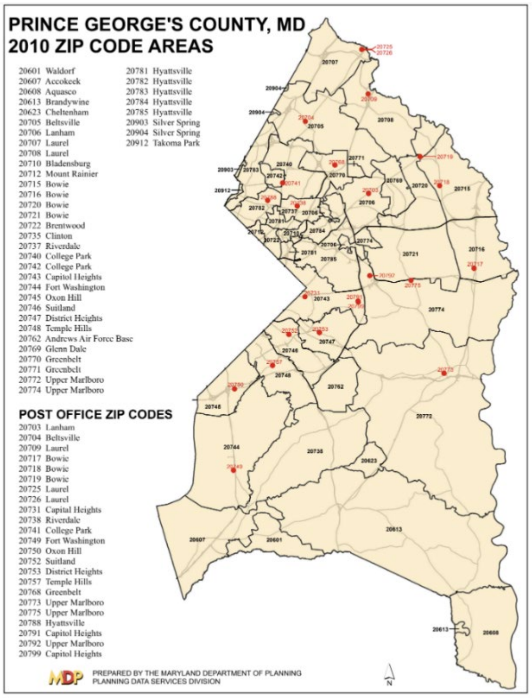

Figure 1. PG County Zip Code Areas (2010). Public domain image from Maryland Department of Planning (http://planning.maryland.gov)

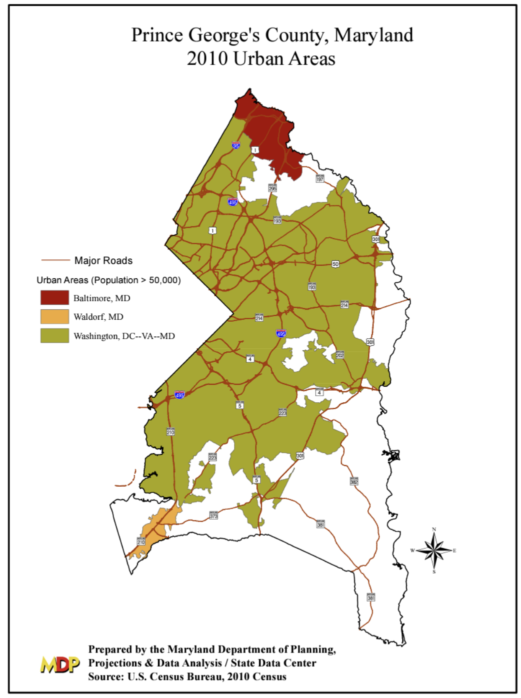

Figure 2. PG County 2010 Urban Areas (2010) Public domain image from Mayland State Archives (https://msa.maryland.gov/msa/mdmanual/36loc/pg/html/pgmu.html

3.2 Data and measures

We employed three types of secondary datasets, including air pollution and environmental degradation data, green environment data and demographic data in our study. We used values for environmental indicators on the EJSCREEN Reports downloaded from the EPA website (https://www.epa.gov/ejscreen) to show environmental degradation levels. These datasets covered all zip code areas and were subsequently imported into ArcGIS for in-depth analysis. Our study incorporated seven environmental variables, as detailed in Table 1. For each variable, we had its raw value for each zip code area, and the national mean value.

Table 1. Major variables.

	Variable	Description
Air Pollution	$PM_{2.5}$	Estimated $PM_{2.5}$ levels in air *(μg/m³ annual avg.)*
	NATA Diesel PM	Estimated diesel particulate matter level in air *(μg/m³)*
	NATA Air Toxics Cancer Risk	Estimated lifetime cancer risk per million from inhalation of air toxics *(lifetime risk per million)*
	NATA Respiratory Hazard Index	Estimated ratio of exposure concentration to health-based reference concentration *(exposure concentration/health-based reference concentration ratio)*
Environmental Pollution	Traffic Proximity	Avg. annual daily traffic volume at major roads within 500 meters divided by distance in meters *(daily traffic count/distance to road)*
	Lead Paint Indicator	Estimated percent of housing units built pre-1960 *(% Pre-1960 Housing)*
	Hazardous Waste Proximity	Count of proposed or listed superfund sites divided by distance in kilometers. *(Facility count/km distance)*
Green Environment	% of Park Area	(Park area/Zip code area) *100%
	% of Tree Canopy Coverage	(Tree canopy coverage area/Zip code area) *100%
Zip Code Demographics	% of Hispanic Children	(Hispanic population aged 0-17/Total population aged 0-17)*100%
	% of African American Children	(African American population aged 0-17/Total population aged 0-17)*100%
	% of White Children	(White population aged 0-17/Total population aged 0-17)*100%
	Median Household Income	Median Household Income ($)
	% of Children Living Below the Poverty Level	(Population aged 0-17 living below the poverty level/Total population aged 0-17)*100%

We obtained data on national standards for select environmental indicators from the EPA website. For $PM_{2.5}$, the annual standard is set at 12.0 μg/m³, and the 24-hour standard is 35 μg/m³. The standard for NATA Air Toxics Cancer Risk is 100 in one million. For the NATA Respiratory Hazard Index, a value of 1 or lower indicates that air toxics are unlikely to cause adverse noncancer health effects over a lifetime of exposure (US EPA, 2018).

Our green environment data was collected from GIS Open Data Portal of Prince George's County Planning Department (https://gisdata.pgplanning.org/opendata/). For each zip code area, we calculated the proportion of the park area and tree canopy coverage area to the zip code area, and used them as indicators of the outdoor green environment.

Children's demographic data was collected from the Health Department of Prince George's County website (http://www.pgchealthzone.org/) on Feb. 2021. Children are defined as the population from age 0 to 17 in this study. We calculated the percentage of children of different races and ethnic groups within the total child population and selected the three most represented groups: Hispanic, African American, and White, for further analysis. Additionally, we obtained data on median household income and percentage of children living below the poverty level from the website to gain insight into their standard of living.

The zip code area data was obtained as a GIS shapefile from Maryland's GIS Data through Maryland.gov (https://data.imap.maryland.gov/). Figure 1 illustrates the distribution and the boundaries of each zip code area in Prince George's County. Of the 63 zip codes shown on the map, 23 post-office zip codes, marked by the red dots, lack specific geographical areas. Additionally, four zip code areas (20601, 20903, 20904, 20912) extend primarily into other counties. Consequently, after removing the 27 zip codes, our study focused on the remaining 36 zip code areas as the subjects of analysis.

3.3 Data Analysis

Using the data described above, we conducted an extensive examination of the relationship between the percentage of children from different racial/ethnic and socio-economic backgrounds, and outdoor environment indicators. Descriptive statistics, correlation, and linear regression analysis were performed with RStudio and SPSS. Descriptive statistics were computed to show the collected data characteristics of the three types of data. Furthermore, we compared the mean value of these data with national averages. In the case of the percentage of park areas, we compared the corresponding values with the State of Maryland's park areas since the national park area percentage was not available for reference. Correlation analysis was used to show the relationships among all the variables under consideration. Linear regression analysis was also applied to evaluate the relationship between the percentage of children of different racial/ethnic and socio-economic backgrounds, and outdoor environment indicators. To facilitate a more comprehensive geographic understanding of differences among zip code areas and trends in data variations, we employed ArcGIS to visualize each variable, categorized into five quantile groups.

4 RESULTS

The results are presented in three parts. First, we employ descriptive statistics to summarize statistics such as means, standard deviations, minimums, and maximums for air and environmental pollution, green environments and zip code demographics variables. In this section, we also performed a geographic analysis of the concentration of pollutants and the spatial distribution of the green environment within the county in GIS. Second, we use correlational analysis to illuminate the relationships among these major variables. Third, we run regression analysis to investigate how household income level, childhood poverty rates, and children's racial and ethnic backgrounds affect their living environment in Prince George's County.

4.1 Descriptive statistics

There are several important characteristics worth noting in Table 2. First, the air quality in PG county, while below the national average level, still met the air quality standards. As shown in Table 2, the averages of all air pollution variables slightly exceeded the national average, which indicates that residents in PG County experienced somewhat higher levels of $PM_{2.5}$, Diesel PM, and higher cancer and respiratory risks compared to the national average. However, these values remained below the established standards set by the United States Environmental Protection Agency (EPA). Specifically, the annual standard for PM2.5 stands at 12.0 µg/m³, the standard for air toxics cancer risk should be below 100 lifetime cancer risk per million from the inhalation of air toxics, and for respiratory hazard Index, a value of 1 or lower signifies that air toxics are unlikely to cause adverse non-cancer health effects over a lifetime of exposure (US EPA, 2018). Even the maximum variables recorded in our data remained below these standards.

Second, the environmental pollution variables in PG County zip codes have a mixed pattern in comparison to national averages. Some variables, such as lead paint exposure indicators and hazardous waste proximity, are below the national average, while others, like annual daily traffic volume, are higher.

Third, PG County has a higher tree canopy coverage compared to national tree canopy coverage rate in the U.S. Additionally, the county has a higher percentage of park areas in comparison to the State of Maryland. These results indicate that people in PG County had more opportunities to get access to green environments.

Lastly, PG County has a high proportion of black children compared to the national average while the average percentage of white children in the zip code areas is well below the national percentage. The average percentage of Hispanic children is roughly in line with the national average; however, specific zip codes have a remarkably high proportion, with almost 83% of the population being Hispanic children. As for income and poverty levels, the median household income among all zip code areas in PG County is $85,862 which is $18,341 higher than the national median household income. Furthermore, the mean percentage of children living below poverty level is 10.4%, which is almost 5.7% less than the national level.

Table 2. Descriptive statistics for major variables.

	Variables	Mean	SD	Minimum	Maximum	National mean
Air Pollution	$PM_{2.5}$ *(μg/m³)*	8.74	0.21	8.11	9.03	8.55
	NATA Diesel PM *(μg/m³)*	0.79	0.20	0.273	1.08	0.478
	NATA Air Toxics Cancer Risk *(lifetime risk per million)*	35.11	2.36	28	38	32
	NATA Respiratory Hazard Index *(exposure concentration/health-based reference concentration ratio)*	0.50	0.05	0.36	0.55	0.44
Environmental Pollution	Traffic Proximity *(daily traffic count/distance to road)*	1026.57	716.58	140	2900	750
	Lead Paint Indicator *(% Pre-1960 Housing)*	0.24	0.18	0.023	0.63	0.28
	Hazardous Waste Proximity *(facility count/km distance)*	1.67	1.14	0.12	3.9	5
Green Environments	% of Park Area	9.05	5.81	0	31.106	6.13*
	% of Tree Canopy Coverage	38.04	13.16	14.25	61.895	33.87
Zip Code Demographics	% of Hispanic Children	25.53	22.44	0	82.60	25.7
	% of African American Children	54.38	26.18	0	88.98	13.8
	% of White Children	16.04	14.74	0	61.76	49.4
	Median Household Income ($)	85,862.29	28,167.97	47,259	156,484	67,521
	% of Children Living Below the Poverty Level	10.39	6.09	0	24.2	16.1

*Compared to the State of Maryland

In GIS, we divided the data of each indicator into five quintile groups and performed the geographical analysis, as depicted in Figure 3 to 5. In the maps, the darker the color indicates the heavier the pollution level or the higher the percentage of green areas. Our findings show that the distribution of air and environmental pollution exhibited overlap. The areas with more serious pollution tend to concentrate mainly in the DVM urban area. The lead paint indicator has a distinct pattern, with higher values in the rural areas in the south, in addition to the urban areas. The distribution map of tree canopy coverage shows that the rural tree cover is significantly higher than that of the urban areas. The distribution of parks, on the other hand, is more scattered, with no clear trend of distribution.

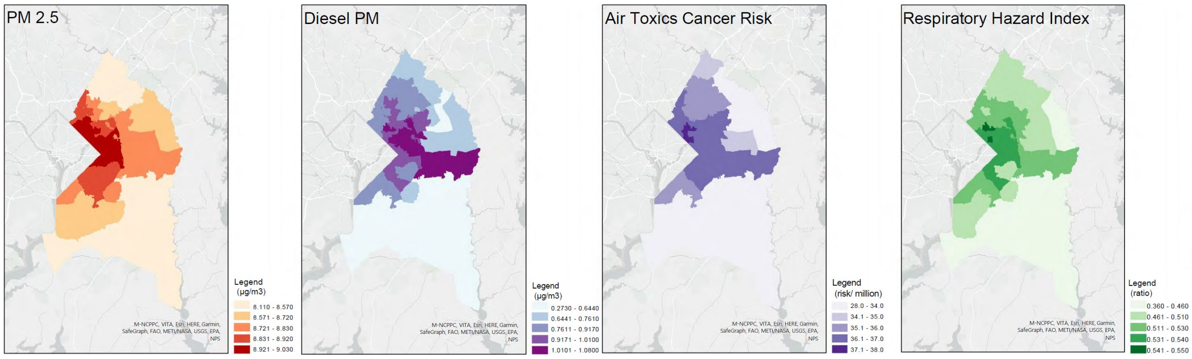

Figure 3. Air pollutant concentration distribution maps (created by the authors).

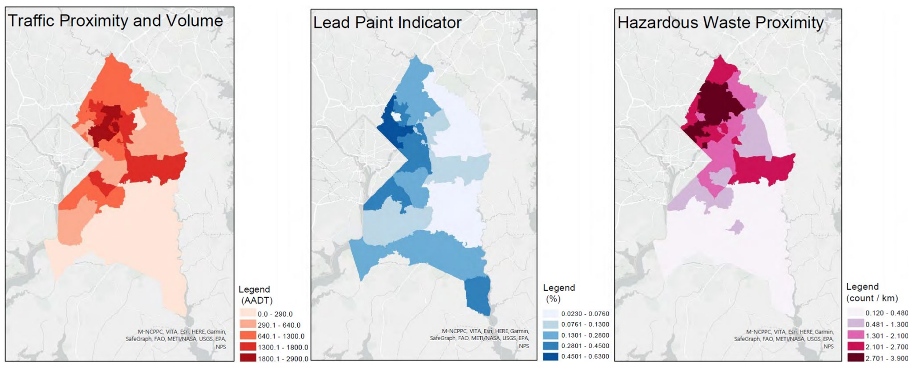

Figure 4. Proximity to pollution sites maps (created by the authors).

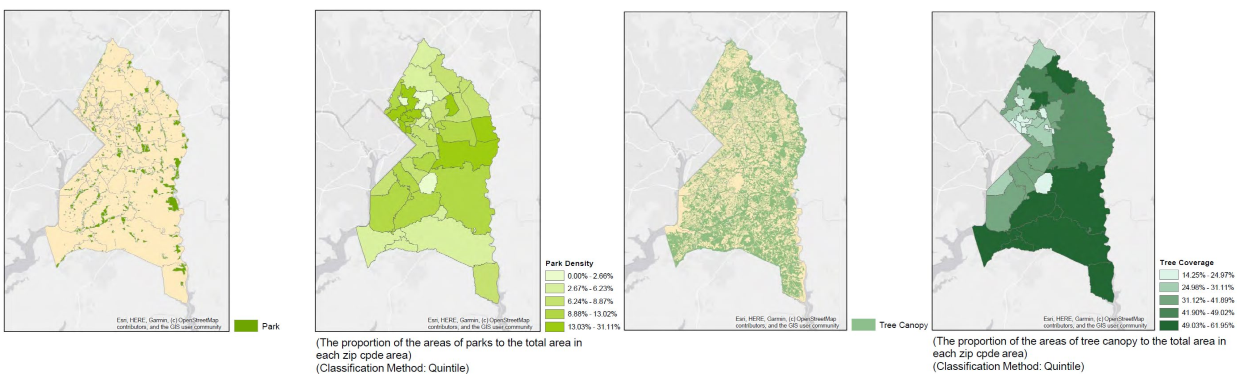

Figure 5. Green environments maps (created by the authors).

4.2 Correlational Analysis

Table 3 shows the correlations among air and environmental pollution, green environments, and the zip code demographics variables. All the air pollution and environmental pollution variables were positive and were significantly correlated with each other. In other words, higher concentrations of air pollutants were associated with an increased risk of cancer and respiratory risks. In addition, higher levels of air pollution indicated higher traffic volume, higher percentage of lead paint indicator and a greater number of hazardous waste facilities within one kilometer. On top of this, all these pollution-related variables were negatively and significantly correlated with the percentage of tree canopy coverage, which indicated that places with more trees tend to have better air quality and living environment in PG County or vice versa. Similarly, air pollution and environmental pollution variables were negatively correlated with median household income levels, which indicated that people with higher income levels tended to reside in locations farther away from pollution sites and enjoyed better air quality. Additionally, median household income was positively correlated with percentage of tree canopy coverage. The only two variables that were positively associated with most pollution-related variables were the percentage of Hispanic children and the percentage of children living below the poverty level. In essence, when the percentages of Hispanic children and children living below the poverty level increased, air and environmental pollution increased as well. Moreover, an increase in the percentage of Hispanic children correlated with a decrease in the percentage of tree canopy coverage.

However, the percentage of African American children demonstrated different patterns. It displayed a positive correlation with tree canopy coverage and a negative correlation with environmental pollution variables and respiratory hazard index. In other words, our results indicate that African American children in PG County lived in places that had higher tree canopy coverage, and lower air and environmental pollution. In addition, there was a negative correlation ($r = -.66$, *** $P \le .001$) between the percentage of African American children and percentage of Hispanic children; and the correlation between the percentage of African American children and white children was also negative ($r = -0.53$, ***$P \le .001$). This might indicate that communities in PG County were not diverse or integrated. People tended to self-sort and live in communities with others like them.

Lastly, other findings revealed that higher percentage of Hispanic children correlated with lower median household income and higher percentage of children living below poverty level. Higher percentage of African American children was positively correlated with median household income; and median household income was negatively correlated with children living below poverty level in Prince George's County.

Table 3. Correlation among major variables.

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. $PM_{2.5}$	1.00												
2. NATA Diesel PM	**0.85** ***												
3. NATA Air Toxics Cancer Risk	**0.90** ***	**0.95** ***											
4. NATA Respiratory Hazard Index	**0.90** ***	**0.96** ***	**0.97** ***										
5. Traffic Proximity	**0.46** **	**0.72** ***	**0.64** ***	**0.71** ***									
6. Lead Paint Indicator	**0.59** ***	**0.53** ***	**0.57** ***	**0.57** ***	**0.43** **								
7. Hazardous Waste Proximity	**0.55** ***	**0.75** ***	**0.74** ***	**0.72** ***	**0.65** ***	**0.63** ***							
8. % of Park Area	**0.31** †	0.18	0.19	0.13	−0.12	**0.40****	0.13						
9. % of Tree Canopy Coverage	**−0.67** ***	**−0.60** ***	**−0.66** ***	**−0.71** ***	**−0.47** **	**−0.50** **	**−0.49** **	0.01					
10. % of Hispanic Children	**0.52** ***	**0.55** ***	**0.59** ***	**0.58** ***	**0.40** *	**0.77** ***	**0.70** ***	**0.34** *	**−0.46** **				
11. % of African American Children	−0.18	−0.24	**−0.31** †	**−0.32** *	**−0.44** **	**−0.47** **	**−0.54** ***	−0.01	**0.60** ***	**−0.66** ***			
12. % of White Children	−0.01	0.06	0.03	0.03	0.17	0.01	0.21	−0.10	−0.19	0.19	**−0.53** ***		
13. Median Household Income	**−0.50** **	**−0.63** ***	**−0.60** ***	**−0.63** ***	**−0.52** **	**−0.56** ***	**−0.58** ***	−0.05	**0.56** ***	**−0.51** **	**0.33** *	−0.04	
14. Children Living Below the Poverty Level	**0.39** *	**0.51** **	**0.50** **	**0.48** **	0.25	**0.47** **	**0.48** **	0.05	−0.21	**0.52** ***	−0.13	0.01	**−0.75** ***

Significance: † $P \le .10$; * $P \le .05$; ** $P \le .01$; *** $P \le .001$

4.3 Regression Analysis

We ran linear regression analysis to investigate the relationship between the percentage of children of different racial/ethnic backgrounds by zip code, the level of air pollution and economic status in their zip codes. According to Table 4, the percentage of Hispanic children and median household income were significant predictors of air pollution variables including $PM_{2.5}$, diesel PM, air toxics cancer risk, and respiratory hazard index. The percentage of African-American children was marginally significant for $PM_{2.5}$ only. Zip code demographic information explained 44 percent ($PM_{2.5}$), 48 percent (cancer risk), and 51 percent (diesel PM and respiratory hazard index) of the air pollution variances.

Table 4. Regression analysis for air pollution.

N = 36	$PM_{2.5}$	NATA Diesel PM	NATA Air Toxics Cancer Risk	NATA Respiratory Hazard Index
% of Hispanic Children	**0.71****	**0.55***	**0.50***	**0.51***
% of African American Children	**0.47†**	0.37	0.16	0.19
% of White Children	0.08	0.12	−0.003	0.02
Median Household Income	**−0.52***	**−0.61****	**−0.47***	**−0.58***
Children Living Below the Poverty Level	−0.32	−0.19	−0.09	−0.20
R^2	**0.44****	**0.51*****	**0.48*****	**0.51*****

Significance: † P ≤ .10; * P ≤ .05; ** P ≤ .01; *** P ≤ .001

The relationship was not that obvious when it came to regression analysis for proximity to environmental pollution sites. As shown in Table 5, the percentage of Hispanic children had a significantly positive association with lead paint indicator and hazardous waste proximity while median household income was only negatively associated with traffic proximity. Zip code demographic information explained 35 percent (traffic proximity), 57 percent (hazardous waste proximity), and 66 percent (lead paint indicator) of the environmental pollution indicators.

Table 5. Regression analysis for environmental pollution.

N = 36	Traffic Proximity	Lead Paint Indicator	Hazardous Waste Proximity
% of Hispanic Children	0.22	**0.74*****	**0.49***
% of African American Children	−0.08	0.04	−0.08
% of White Children	0.06	−0.12	0.06
Median Household Income	**−0.59***	−0.29	−0.31
Children Living Below the Poverty Level	−0.30	−0.13	−0.02
R^2	**0.35***	**0.66*****	**0.57*****

Significance: † P ≤ .10; * P ≤ .05; ** P ≤ .01; *** P ≤ .001

For green environments, park percentage and tree canopy coverage percentage, we found that the percentage of Hispanic and African American children was positively associated with park percentage (see Table 6). For tree canopy coverage, the percentage of Hispanic and white children were negatively associated with tree canopy coverage percentage. However, median household income is positively associated with tree canopy coverage. The percentage of African American children is marginally significant for park percentage while the percentage of white children is marginally significant for tree canopy coverage percentage only. All other relationships were statistically significant. The explained variance for tree canopy coverage by zip code level children's demographics, household income and childhood poverty were much higher (52%) compared to the percentage of parks variable (28%).

Table 6. Regression analysis for green environments.

N = 36	Park Percentage	Tree Canopy Coverage Percentage
% of Hispanic Children	**0.88****	**−0.52***
% of African American Children	**0.57†**	−0.15
% of White Children	0.03	**−0.27†**
Median Household Income	−0.09	**0.51***
Children Living Below the Poverty Level	−0.40	0.25
R^2	**0.28†**	**0.52*****

Significance: † P ≤ .10; * P ≤ .05; ** P ≤ .01; *** P ≤ .001

5 DISCUSSION AND CONCLUSIONS

Socioeconomic status, characterized by household income and ethnicity, strongly influences the quality of outdoor spaces available to children. This study confirms the relationship between tree canopy coverage and air quality that places with more trees are more likely to have better air quality. When analyzing the association between poverty and outdoor environment, median household income was a better predictor than children living below poverty level because its associations with most environmental factors were significant in the analysis. The study shows that children living in low-income households are more likely to be exposed to more toxic air conditions and live in places with less tree canopy coverage. This result is consistent with the findings of most existing studies that children living in poverty regardless of race or other urban setting are more likely to lack access to quality green space and more vulnerable to air pollution (Evans, 2004; Perera, 2017; VanSickle & Coutts, 2022).

Considering the ethnicity of children, the percentage of Hispanic children is positively related to the percentage of children living below poverty level and inversely related to the median household income level in PG County. The results indicate that Hispanic children in PG County are more likely than the children of other races to live in areas with higher levels of air pollution and less tree cover. From the perspective of distributive inequity, Hispanic children in PG County lived in zip codes burdened by greater air and environmental pollution. At the same time, vegetation cover is not equally distributed to all children, signifying that access to green spaces is not equitable. Carter-Pokras et al. (1990) also found that Mexican American children are more likely to be exposed to deteriorating lead paint because they are more likely to live in older housing and in inner cities. Another of his studies (2007) explains that Latino families with children have greater likelihood of living in public, rental housing, or multifamily units with outdoor environments in poor condition, thus they may struggle to improve their living environment that would be desirable to modify. While this study focuses on a specific region, it sheds light on the broader environmental injustices experienced by Hispanic children. As a result, it underscores the significance of policymakers acknowledging this community in their future decision-making processes and actively work toward achieving environmental justice.

To address these disparities, corrective strategies should ensure that affected communities receive compensation and funding support to enhance their living environments. These communities should also actively participate in future planning processes (US EPA, 2015). Industrial facilities that produce air and environmental pollution should be required to clean their pollution within their properties. Moreover, new industrial facility permits should not be granted in Hispanic neighborhoods that already bear a significant pollution burden. In terms of tree planting and park construction, a "bottom-up" approach should be encouraged to plan for greening in low-income neighborhoods, as well as places where historically marginalized groups reside (VanSickle & Coutts, 2022). Strategies can include local communities engaging in the production of space, such as through the creation of community gardens, or other forms of collective green spaces (VanSickle & Coutts, 2022).

Currently, the State of Maryland has initiated several tree planting programs including “Marylanders Plant Trees”, “Lawn to Woodland”, and “Forest Conservation Management Program”, etc. to encourage afforestation and forestation (*Tree Planting Programs*, n.d.). In 2021, the State passed legislation in support of planting and maintaining 5 million native trees in Maryland by 2031, with a key focus of supporting tree equity through tree planting in underserved urban communities (“State of Maryland - Growing Five Million Trees by 2030,” n.d.). To achieve this goal, the study recommends prioritizing tree planting efforts in communities with a high percentage of low-income families and Hispanic children in Prince George's County.

Several limitations should be considered when reading these results. First, the study only analyzed the percentage of park space, i.e., size and accessibility, in its zip code area, but not the quality of these parks. As some existing studies have shown, although some neighborhoods are within walking distance of parks, the quality of the parks, such as maintenance, condition of facilities, etc. can be substandard (Rigolon, 2017). Therefore, the areas with higher park percentage in this paper can only indicate that residents in these areas have easier access to more park space, but not enough to indicate that they have access to higher-quality outdoor spaces. Second, the associations found in this study cannot be considered causal or universal. The study was conducted in a small and non-random-selected sample of only 36 zip code areas in Prince George’s County. Thus, the results of this study cannot be extrapolated to other populations due to differences in geographic variations, ethnic composition, socio-economic backgrounds, etc. Third, compared to individual-level analysis, zip code level data analysis may cause certain errors and thus is not representative. The next step of the study might be to narrow the study area to individual neighborhoods and blocks and conduct on-site research and interviews.

REFERENCES

Bai, H., Wilhelm Stanis, S. A., Kaczynski, A. T., & Besenyi, G. M. (2013). Perceptions of Neighborhood Park Quality: Associations with Physical Activity and Body Mass Index. *Annals of Behavioral Medicine*, *45*(suppl_1), S39–S48. https://doi.org/10.1007/s12160-012-9448-4

Carter-Pokras, O., Pirkle, J., Chavez, G., & Gunter, E. (1990). Blood lead levels of 4-11-year-old Mexican American, Puerto Rican, and Cuban children. *Public Health Reports (Washington, D.C. : 1974)*, *105*(4). http://pubmed.ncbi.nlm.nih.gov/2116641/

Carter-Pokras, O., Zambrana, R. E., Poppell, C. F., Logie, L. A., & Guerrero-Preston, R. (2007). The Environmental Health of Latino Children. *Journal of Pediatric Health Care : Official Publication of National Association of Pediatric Nurse Associates & Practitioners*, *21*(5), 307. https://doi.org/10.1016/j.pedhc.2006.12.005

Chen, S., Christensen, K. M., & Li, S. (2019). A comparison of park access with park need for children: A case study in Cache County, Utah. *Landscape and Urban Planning*, *187*, 119–128. https://doi.org/10.1016/j.landurbplan.2019.04.001

Dunton, G. F., Almanza, E., Jerrett, M., Wolch, J., & Pentz, M. A. (2014). Neighborhood Park Use by Children: Use of Accelerometry and Global Positioning Systems. *American Journal of Preventive Medicine*, *46*(2), 136–142. https://doi.org/10.1016/j.amepre.2013.10.009

Evans, G. W. (2004). The Environment of Childhood Poverty. *American Psychological Association*, *59*(2), 77–92. https://doi.org/10.1037/0003-066X.59.2.77

Gardiner, B. (2021, April). The Deadly Cost of Dirty Air. *National Geographic*. https://discovery.ebsco.com/c/u2yil2/viewer/html/7irhvt2mvj

Growing Cities. (n.d.). *Child Friendly Cities Initiative*. Retrieved December 16, 2022, from https://childfriendlycities.org/growing-cities/

Henry, J. (2019, March 7). *Prince George's County: How a community grappled with racism to become a destination for African-Americans*. Wusa9.Com. https://www.wusa9.com/article/news/local/maryland/prince-georges-county-how-a-community-grappled-with-racism-to-become-a-destination-for-african-americans/65-3a70f85d-9216-4283-9ac7-668b51398b6f

Landrigan, P. J., Fuller, R., Acosta, N. J. R., Adeyi, O., Arnold, R., Basu, N. (Nil), Baldé, A. B., Bertollini, R., Bose-O'Reilly, S., Boufford, J. I., Breysse, P. N., Chiles, T., Mahidol, C., Coll-Seck, A. M., Cropper, M. L., Fobil, J., Fuster, V., Greenstone, M., Haines, A., … Zhong, M. (2018). The Lancet Commission on pollution and health. *The Lancet*, *391*(10119), 462–512. https://doi.org/10.1016/S0140-6736(17)32345-0

Landry, S. M., & Chakraborty, J. (2009). Street Trees and Equity: Evaluating the Spatial Distribution of an Urban Amenity. *Environment and Planning A: Economy and Space*, *41*(11), 2651–2670. https://doi.org/10.1068/a41236

Lanza, K., Alcazar, M., Hoelscher, D. M., & Kohl, H. W. (2021). Effects of trees, gardens, and nature trails on heat index and child health: Design and methods of the Green Schoolyards Project. *BMC Public Health*, *21*(1), 98. https://doi.org/10.1186/s12889-020-10128-2

Locke, D. H., Hall, B., Grove, J. M., Pickett, S. T. A., Ogden, L. A., Aoki, C., Boone, C. G., & O'Neil-Dunne, J. P. M. (2021). Residential housing segregation and urban tree canopy in 37 US Cities. *Npj Urban Sustainability*, *1*(1), Article 1. https://doi.org/10.1038/s42949-021-00022-0

López-Gil, J. F., Chen, S., Smith, L., Gutie´rrez-Espinoza, H.´ector, Victoria-Montesinos, D.´ee, Iglesias, J. N., T´arraga-L´ opez, P. J., & Mesas, A. E. (2022). What is the role of particulate matter 2.5 (PM2.5) on excess weight? A cross-sectional study in young Spanish people aged 2–14 years. *Environmental Research*. https://doi.org/10.1016/j.envres.2022.114561

López-Gil, J. F., García-Hermoso, A., Cavero-Redondo, I., Ortega, F. B., Gómez, S. F., & Martínez-Vizcaíno, V. (2022). Association between air pollution and 24-h movement behaviours in a representative sample of Spanish youth. *Environmental Research*, *214*, 113996. https://doi.org/10.1016/j.envres.2022.113996

Loukaitou-Sideris, A., & Sideris, A. (2009). What Brings Children to the Park? Analysis and Measurement of the Variables Affecting Children's Use of Parks. *Journal of the American Planning Association*, *76*(1), 89–107. https://doi.org/10.1080/01944360903418338

Maryland Department of Planning. (n.d.). Planning. Retrieved January 14, 2023, from https://planning.maryland.gov/Pages/default.aspx

Nutsford, D., Pearson, A. L., & Kingham, S. (2013). An ecological study investigating the association between access to urban green space and mental health. *Public Health*, *127*(11), 1005–1011. https://doi.org/10.1016/j.puhe.2013.08.016

Owens, P. E. (2017). A place for adolescents: The power of research to inform the built environment. In *Designing Cities with Children and Young People: Beyond Playgrounds and Skate Parks* (pp. 65–78). Scopus. https://doi.org/10.4324/9781315710044

Perera, F. P. (2017). Multiple Threats to Child Health from Fossil Fuel Combustion: Impacts of Air Pollution and Climate Change. *Environmental Health Perspectives*, *125*(2), 141–148. https://doi.org/10.1289/EHP299

Razani, N., Meade, K., Schudel, C., Johnson, C., & Long, D. (2015). Healing through Nature: A Park-Based Health Intervention for Young People in Oakland, California. *Children, Youth and Environments*, *25*(1), 147–159. https://doi.org/10.7721/chilyoutenvi.25.1.0147

Ries, A. V., Gittelsohn, J., Voorhees, C. C., Roche, K. M., Clifton, K. J., & Astone, N. M. (2008). The environment and urban adolescents' use of recreational facilities for physical activity: A qualitative study. *American Journal of Health Promotion: AJHP*, *23*(1), 43–50. https://doi.org/10.4278/ajhp.07043042

Rigolon, A. (2017). Parks and young people: An environmental justice study of park proximity, acreage, and quality in Denver, Colorado. *Landscape and Urban Planning*, *165*, 73–83. https://doi.org/10.1016/j.landurbplan.2017.05.007

Rothstein, R. (2017). *The Color of Law: A Forgotten History of How Our Government Segregated America* (Illustrated edition). Liveright.

State of Maryland—Growing Five Million Trees by 2030. (n.d.). *1t Org U.S.* Retrieved January 2, 2023, from https://us.1t.org/pledge/state-of-maryland-growing-five-million-trees-by-2030/

Taylor, A. F., Wiley, A., Kuo, F. E., & Sullivan, W. C. (1998). Growing Up in the Inner City: Green Spaces as Places to Grow. *Environment and Behavior*, *30*(1), 3–27. https://doi.org/10.1177/0013916598301001

Tree Planting Programs. (n.d.). Maryland Department of Natural Resources. Retrieved January 2, 2023, from https://dnr.maryland.gov/forests/Pages/default.aspx

US EPA. (2014, April 10). *Criteria Air Pollutants* [Other Policies and Guidance]. https://www.epa.gov/criteria-air-pollutants/naaqs-table

US EPA, O. (2015, February 13). *Learn About Environmental Justice* [Overviews and Factsheets]. https://www.epa.gov/environmentaljustice/learn-about-environmental-justice

US EPA, O. (2018, July 9). *2014 NATA: Assessment Results* [Reports and Assessments]. https://www.epa.gov/national-air-toxics-assessment/2014-nata-assessment-results

VanSickle, M., & Coutts, C. (2022). Considerations for Children's Nature Connection and Park Environmental Justice in Western Societies. *Land*, *11*(9), 1435. https://doi.org/10.3390/land11091435

Watts, N., Adger, W. N., Agnolucci, P., Blackstock, J., Byass, P., Cai, W., Chaytor, S., Colbourn, T., Collins, M., Cooper, A., Cox, P. M., Depledge, J., Drummond, P., Ekins, P., Galaz, V., Grace, D., Graham, H., Grubb, M., Haines, A., … Costello, A. (2015). Health and climate change: Policy responses to protect public health. *The Lancet*, *386*(10006), 1861–1914. https://doi.org/10.1016/S0140-6736(15)60854-6

Wolch, J., Jerrett, M., Reynolds, K., McConnell, R., Chang, R., Dahmann, N., Brady, K., Gilliland, F., Su, J. G., & Berhane, K. (2011). Childhood obesity and proximity to urban parks and recreational resources: A longitudinal cohort study. *Health & Place*, *17*(1), 207–214. https://doi.org/10.1016/j.healthplace.2010.10.001

WHO. (2022, December 19). *Ambient (outdoor) air pollution*. World Health Organization. https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health.