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Impacts of Air Pollution on the Respiratory System of Adults in Relation to Socioeconomic Status

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SUMMARY

Air pollution has many negative effects on the body, especially on the respiratory system. However, thorough summaries on this topic are limited, especially in relation to other factors, such as income, education, and occupation. This study summarizes existing research on this topic and outlines important steps for the future. It was found that air pollution aggravates multiple lung problems, such as coughing, wheezing, chronic obstructive pulmonary disease, asthma, and cystic fibrosis. Small solid particles were usually the culprit of this because they can pass through lung filters and damage tissues. This is problematic for lower-income individuals, as they tend to live near industrial areas where air pollution is high. Unfortunately, many countries take this matter less seriously than others. Some measures that were taken to tackle this issue, including introducing more green spaces to allow for trees to absorb air pollutants, resulting in improved air quality. However, the effects were minimal. In the future, there needs to be more research on the health impacts of air pollution and how it can be effectively tackled on a policy level, especially for low-income families.

ABSTRACT

Air pollution has a significant impact on respiratory health, yet comprehensive summaries of specific impacts are limited. This study reviews previous research done on this link, while connecting it to socioeconomic factors. Common air pollutants, such as particulate matter, have a large impact on respiratory health and can exacerbate diseases and medical conditions, such as coughing, wheezing, chronic obstructive pulmonary disease, asthma, and cystic fibrosis. Specifically, PM_{10} pollutants can deposit in the upper airways, and $PM_{2.5}$ can reach deep into the lungs, leading to many complications. The efficacy of measures taken to combat these issues are also discussed. In recent years, governments have introduced national climate policies and green-space designs in urban municipalities to reduce negative health outcomes. These measures accomplish this goal to a limited degree but require further investment and development. To outline how socioeconomic status impacts air pollution-related respiratory illnesses, our study discusses five studies investigating socioeconomic disparities in air pollution exposure in various parts of the world. Evidence shows that low-income people typically reside in areas with high air pollution because housing is more affordable. This provides an opportunity for new research in social determinants of health to better understand its connection with human health.

Keywords: Human health, impact of air pollution, respiratory health, socioeconomic factors, public health

INTRODUCTION

Air pollution refers to the presence of harmful particles in the atmosphere.[1] This includes gasses, such as nitrogen oxide, sulfur dioxide, carbon monoxide, polycyclic aromatic hydrocarbons (PAHs), and many more.[1]

Another type of air pollutant is called particulate matter (PM), which are solid particles with a very small diameter dispersed in the air.[2] These are mainly emitted into the atmosphere from the burning of fossil fuels.[2] This includes but is not limited to the use of gasoline and diesel-based automobiles, factories, and coal power plants. However, natural sources of air pollutants also exist in the form of volcanoes, wildfires, etc.[1] The sources of the most abundant air pollutants are further explained in Table 1. In addition, these pollutants are linked to negative effects on human health.[1] For example, long-term exposure to nitrogen dioxide (NO_2) can impair a person's ability to smell.[3] Furthermore, exposure to carbon monoxide (CO) can induce symptoms, such as headaches, nausea, and vomiting.[4] However, there is a notably high impact of air pollution on the respiratory system, which is why it will be the primary focus of our paper.

The purpose of this review is to provide a critical analysis of the effects of air pollution on the respiratory system and its potential link to socioeconomic status. The term socioeconomic status (SES) defines the social standing of people or their class. It is primarily based on the dimensions of income, occupation, and education.[6-8] A person of high SES is one who is well educated, has a high income, and/or holds a high-ranking position within their occupation. In contrast, people considered to hold a low SES are characterized by lower education levels, low income, and having less prosperous occupations. Previous studies have investigated the link between air pollution and specific respiratory disorders or the association between air pollutant concentrations and SES; however, few studies have attempted to connect the two on a larger scale. Our article aims to inspire advancements in the disciplines of respiratory health, environmental pollution, and socioeconomic status. Our goal is to encourage other scholars to conduct more studies in these areas worldwide to discover if the link between them is consistent.

Table 1. Artificial and natural sources of common air pollutants sulfur dioxide, carbon monoxide, nitrogen oxide, and particulate matter. The information within this table was derived from a study conducted by the IARC Working Group on the Evaluation of Carcinogenic Risks to Humans.[5]

Air pollutant:	Artificial Sources:	Natural Sources:
Sulfur dioxide (SO_2)	Fossil fuel combustion through gasoline/diesel -powered vehicles, metal processing facilities, etc.	Volcanic eruptions, oceanic microbial activity, anaerobic degradation of organic matter, etc.
Carbon monoxide (CO)	Incomplete combustion of fossil fuels by gasoline/diesel -powered vehicles, combustion of biomass, etc.	Volcanic eruptions, wildfires, etc.
Nitrogen oxide (NO)	Fossil fuel combustion through gasoline/diesel -powered vehicles, power plants, agricultural fertilizers, etc.	Lightning strikes, stratospheric oxidation of nitrous oxide (N_2O) etc.
Particulate matter (PM)	Fossil fuel combustion by gasoline/ diesel-powered vehicles, vehicular abstraction, fugitive dust emission from mining, etc.	Volcanic eruptions, wind driven disbursement of dust, pollen, etc.

Within this paper, the effects of air pollution on the respiratory system, such as coughing, wheezing, chronic obstructive pulmonary disease (COPD), asthma, and cystic fibrosis are discussed first. Then, the discussion shifts to the various socioeconomic factors associated with the frequency of air pollution, which include the locations where low SES individuals live and the quantity of green space around their neighbourhoods.

2. IMPACT OF AIR POLLUTION ON THE RESPIRATORY SYSTEM

Air pollution has been proven to have many negative effects on human health. It is a known contributor to stroke, brain damage, cancer, and most of all, acute and chronic effects on respiratory health.[9,10]

These adverse effects on respiratory health are primarily brought about by air pollutants, such as nitrogen oxides (NO_x), ozone (O_3), sulfur dioxide (SO_2), carbon monoxide (CO), and particulate matter (PM).[11] These pollutants affect different parts of the respiratory system, leading to increasingly more severe health outcomes, ranging from minor respiratory irritations to chronic respiratory disease, lung cancer, lung infections, etc.[11]

An air pollutant with strong evidence linked to adverse health effects on the respiratory system, is particulate matter. Often used as a measure of air pollution, two important types of particulate matter which will be discussed in depth are coarse particulate matter (PM_{10}) and fine particulate matter ($PM_{2.5}$). These particles have a diameter smaller than 10μm and 2.5μm, respectively.[12] Coarse particulate matter mainly deposits in the upper airways and the trachea, whereas fine particulate matter can penetrate deep inside the lungs.[12] Fine particulate matter is also associated with cardiorespiratory disease and mortality. Both types of particulate matter can cause symptoms, such as persistent coughing, wheezing, and inflammation in the airways which exacerbates chronic obstructive pulmonary disease (COPD), cystic fibrosis, and asthma.[12, 13]

2.1 COUGHING & WHEEZING

Air pollution leads to an increased frequency of wheezing. Specifically, PM_{10} and $PM_{2.5}$ pollutants enter the respiratory tract and cause bronchoconstriction.[3] Additionally, $PM_{2.5}$ can corrode the alveolar wall, reducing overall lung function.[14] The presence of foreign material in the lungs was also found to induce inflammatory responses in the respiratory tract, such as the increased presence of phlegm.[15] All these factors combined can cause wheezing in subjects for long periods of time, which can make their breathing laboured.[12]

Furthermore, air pollution can cause significant coughing when inhaled. For instance, sulfur dioxide (SO_2) is a common air pollutant and a well-known respiratory tract irritant.[15] Thus, when sulfur dioxide is inhaled, it is converted into bisulfite (HSO_3^-), which affects sensory receptors in the lungs and causes bronchoconstriction.[1] More importantly, inhalation of $PM_{2.5}$ pollutants can lead to persistent coughing because these particles are small enough to enter the walls of the larynx and trachea, agitating the area.[12, 16] Additionally, these particles typically induce an inflammatory response, which increases phlegm and ultimately aggravates coughing. Within elderly patients, this persistent coughing causes fatigue and eventually leads to fluid buildup in the lungs and subsequent onset of pneumonia.[17]

2.2 CHRONIC OBSTRUCTIVE PULMONARY DISEASE

Chronic obstructive pulmonary disease (COPD) is typically diagnosed in people who have long-term complications with breathing, specifically due to the limited amount of airflow allowed to reach the lungs. This airflow is typically restricted because of inflammation from consistent particulate matter and/or noxious gas exposure.[18] According to the World Health Organization, COPD is responsible for 3.23 million deaths in 2019 and is the third leading cause of death worldwide.[19]

In most cases, COPD is caused by cigarette smoking; however, especially in recent years, poor air quality arising from pollution has also raised questions as to whether it can increase one's risk of COPD.[12]

One study evaluated non-smoking individuals in China who were over the age of 50 through spirometry.[20] Spirometry is a common test which measures a person's lung functional integrity. By using this technique, Lam and colleagues diagnosed COPD those who had a forced expiratory volume (FEV) to forced vital capacity (FVC) ratio less than the lower limit of normal (LLN – which was predicted from Chinese populations). Interviews were also conducted with participants of the study to understand their occupation and personal lifestyle.[20] Overall, this study found that COPD diagnosis has a positive association with those who have a high exposure to air polluted environments. Moreover, occupational exposure to polluted air was found to be the most vulnerable risk factor for COPD.[20] Lam and researchers did not analyze specific air pollutants; however, further research by Doiron and colleagues (2019) narrowed on the key pollutants.

Specifically, Doiron's team assessed concentrations of specific noxious gasses in comparison to lung function. They discovered that $PM_{2.5}$ concentration increases of $5 \mu g \cdot m^{-3}$ were associated with decreases in FEV. This finding explains why researchers also observed an increased prevalence of COPD in areas that contained higher concentrations of $PM_{2.5}$. Areas with higher concentrations of PM_{10} and NO_2 also noticed a greater prevalence of COPD.[21] Therefore, $PM_{2.5}$, PM_{10}, and NO_2 are all significant air pollutant culprits in lung physiology.

It is important to note that although these findings are promising when it comes to making connections between air pollution and COPD, such observations are not always replicable and are inconclusive instead.[22] Therefore, more research is warranted in this field to gain a firmer grasp on the issue and to investigate a definite connection.

2.3 ASTHMA

Asthma is a well-known, chronic respiratory disease that can be defined by obstruction of airflow, airway inflammation, and bronchial hyperresponsiveness, an increase in sensitivity to a wide variety of airway narrowing stimuli.[23] The disease is characterized by a variety of respiratory symptoms including wheezing, dyspnoea, coughing, and tightness of chest. The prevalence of asthma ranges from between 1% and 18% in countries globally.[24] There is increasing evidence that shows a connection between indoor and outdoor air pollution and new-onset asthma.

A main contributor to asthma development is traffic-related air pollution (TRAP) and power generation, creating a pollutant mixture that not only contains components such as $PM_{2.5}$, PM_{10}, NO_2 and black carbon, but also rich in particulate matter.[25] There is also evidence that outdoor air pollution can exacerbate preexisting asthma conditions. Urbanization is an important contributor to asthma, which is due to increased outdoor air pollution.[25] Since many regions are developing and experiencing growing populations (resulting in increased levels of air pollution), the global burden of asthma is likely to increase.

Why are individuals with asthma susceptible to air pollution? When looking at areas with high concentrations – for example, Delhi, India – air pollutants may have direct inflammatory effects accompanied with more serious health concerns.[25] However, cases of high concentrations are not common in higher-income locations, such as Melbourne in Australia. At these lower concentrations, specific pollutants can contribute to features of asthma. For example, ozone, nitrogen dioxide, and $PM_{2.5}$ can potentially contribute to airway inflammation. Also, ozone and nitrogen dioxide are contributors to bronchial hyperresponsiveness.[25] In more severe cases of asthma, oxidative stress (the imbalance between oxygen reactive species and anti-oxidative abilities of the body) can be associated with ozone, nitrogen dioxide, and $PM_{2.5}$.[26] Although there are links between the specific pollutants and features of asthma, the exact mechanisms and processes by which the pollutants influence asthma are not known and require more research.

2.4 CYSTIC FIBROSIS

2.4.1 Pathophysiology of CF pulmonary exacerbation and clinical epidemiology of CF pulmonary exacerbation

The pulmonary system, namely the upper and lower airways, is responsible for the morbidity and death associated with cystic fibrosis (CF).[27] Based on *in vitro* evidence, the postulated mechanism of CF airway illness is the volume of periciliary lining fluid decreases relative to the dryness of the layer. Relative dryness of the layer occurs due to sodium hyperabsorption and lack of chloride absorption.[27] This results in reduced fluid volume, poor ciliary function, and delayed mucociliary transfer, allowing germs to thrive. When there is infection, neutrophils (a type of white blood cell from the immune system) are drawn to the airway while producing proinflammatory cytokines. These cytokines create a vicious cycle of persistent infection and inflammation that eventually damages the airways.[27]

Despite our deep understanding of CF at the cellular level, relatively little is known about the pathophysiology of exacerbations — recurring bouts of worsening pulmonary symptoms.[27] Exacerbations of pulmonary illness are quite prevalent and reflect clinically as changes in cough, sputum output, dyspnoea, reduced energy and appetite, weight loss, and declines in spirometric parameters. These events are most likely connected to a complicated interplay between host defense and airway microbiology, which influences sputum production and airflow restriction.[27] Although data on the impact of immunization against viral infection is sparse, viral infections, especially respiratory syncytial virus, may play a role in the onset of these events.[27-30] Aggravations of pulmonary disease have also been linked to the acquisition of additional organisms or a change in the bacterial density of the colonizing flora.[27, 31-34]

Some of the symptoms of exacerbation of cystic fibrosis include a fever; increase in coughing rates by 50%; a 10 breath-per-minute rise in respiratory rate; 50% increase in sputum volume; decrease in forced vital capacity of at least 10%; symptoms of upper respiratory tract infections; appetite loss and a weight loss of at least 1 kg; a peripheral blood neutrophil count of 15000 or higher per cubic millimeter; and absence from school or work (at least three or the previous seven days) due to sickness.[35]

2.4.2 Pulmonary exacerbation rates

Rates of CF pulmonary exacerbation rise with age and severity of pulmonary impairment.[27] A pulmonary exacerbation is defined as a CF-related lung disease that necessitated hospitalization or the use of home intravenous antibiotics. When participants reach adolescence and young adulthood, the proportion of CF patients who have at least one pulmonary exacerbation each year increases. Adults have a linear association with rising exacerbation rates and decreasing lung function.[27]

2.4.3 Pulmonary exacerbation and air pollutants

Past research has found that increasing yearly average exposure to ambient air pollutants, especially PM_{10}, $PM_{2.5}$, and ozone, relates to an increased risk of two or more pulmonary exacerbations in CF patients. The link is strongest among individuals who have two or more exacerbations per year.[36] Even when there are no symptoms, CF patients have signs of airway infection, inflammation, and tissue breakdown products; the process that leads to the deterioration of the integrity of the CF airway is lifelong.[36]

The CF lung has high quantities of free white blood cells and their enzymes (myeloperoxidase and neutrophil-derived proteases), as well as low levels of different enzymes which impact the airways, such as S-nitrosoglutathione.[37] This means that air pollutants might irritate and injure the airways more in environments of high oxidative stress and inflammation. In turn, this may impact the rate of airway infection as well as its severity.[36] Also, it is important to note that $PM_{2.5}$ and PM_{10} exhibited the most consistent relationships with significant clinical outcome markers in this study. This conclusion may be supported by recent research in CF patients, but further research is warranted.[36]

3.0 SOCIOECONOMIC VARIABLES RELATED TO PREVALENCE OF AIR POLLUTION

A person of SES is one who is well educated, has a high income, and/or holds a high-ranking position within their occupation. In contrast, people considered to hold a low SES are characterized by lower education levels, low income, and having less prosperous occupations. Although SES is usually based on a combination of income, occupation, and education, they do not always need to be present together to determine a person's SES.[6] For example, a person may not be well-educated and yet may own multiple successful companies. This person would still be characterized as having a high SES. In contrast, another individual may hold a PhD designation and yet have a low-income level. This individual would be characterized as having a low-to-middle socioeconomic status.

SES contains many economic and societal forces that affect health. Examples of economic and societal forces on health can be seen in Table 2.

Table 2. Examples of economic and societal forces on health

Income	Occupation	Education
Spending power	Responsibility	Skills and qualifications needed social and economic resources
Housing	Prestige	
Diet	Work opportunities	
Medical care	Recreation opportunities	

3.1 STUDIES ON SOCIOECONOMIC DISPARITIES IN AIR POLLUTION EXPOSURE

One study conducted by Fan and colleagues, researched the impact of socioeconomic status on air pollution exposure in Hong Kong.[39] The specific levels of air pollutants assessed included carbon monoxide, nitrogen oxides, sulfur dioxide, and PM_{10}.[39] It was found that within the private housing market, there was a considerable inequality in exposure to air pollution. Specifically, neighbourhoods comprising lower SES families had higher levels of air pollution compared to higher SES neighbourhoods, and the greatest disparity was found for the air pollutant PM_{10}.[39] Interestingly, public housing provided by the government for lower SES families had lower air pollution levels than similar neighbourhoods in the public housing market.[39] This demonstrates that government intervention in the housing market is a potential strategy for reducing SES disparities.

Another study by Rooney et al. (2012) found that community SES was inversely associated with particulate matter pollution.[40] This study was conducted in four communities: Jamestown/Ushertown, Asylum Down, Nima, and East Legon in Accra, Ghana.[40] The results showed that particulate matter pollution was higher in low SES neighbourhoods with $PM_{2.5}$ and PM_{10}. The $PM_{2.5}$ and PM_{10} concentrations were 34% and 20% higher, respectively, in the lowest SES neighbourhood compared to the highest SES one.[40] Sources of pollution in these communities included transportation, dust from unpaved roads, household/small business biomass stoves and fuel burning, and trash burning. Moving forward, financial support and increased accessibility to alternative fuels for lower-income communities will help reduce/limit air pollution.[40]

Furthermore, few studies have investigated differential vulnerability to air pollution by socioeconomic status, and all have been concentrated in one or a few cities in a single country.[41-46] These studies consistently found that subjects of SES are more vulnerable to the health impacts of air pollution, independent of exposure.[46, 47] As a result, differential exposure and susceptibility to air pollution may contribute to the persistence of health inequalities in Europe.[46, 48] However, the extant European research is restricted in breadth, raising concerns about the conclusions' generalizability to other contexts, notably Eastern Europe.[46] Additionally, one study looked at Europe as a whole and considered if low-income European people were: (a) exposed to disproportionately high levels of particle air pollution (PM_{10}) and/or (b) disproportionately vulnerable to pollution-related death consequences.[46]

The study discovered evidence of environmental disparity. The double disadvantage of low income and bad air quality was disproportionately concentrated in Eastern European regions and was drove the Europe-wide association.[46] Lower-income populations were more vulnerable to the impacts of PM_{10}, but only in terms of cardiovascular disease mortality in Eastern Europe and male respiratory mortality in Western Europe.[46] They discovered considerably higher odds of male and female cardiovascular- and- respiratory- illness-caused death and female all-cause mortality in Eastern European locations.[46] Thus, income-related disparities in exposure to ambient PM_{10} may contribute to Eastern European-wide mortality disparities.[46]

Another study, conducted by Su and colleagues (2010), found similar results with median household income as a socioeconomic variable, and its association with air pollution in two major North American cities: Vancouver and Seattle.[49] Specifically, nitrogen dioxide (NO_2) levels were utilized as a measure of air pollution and were compared to census data taken from these cities.[49] At the end of the study, the strongest and most consistent negative correlation existed between NO_2 concentration levels and median household income of a neighbourhood. For example, the higher the median household income, the lower the observed NO_2 concentration levels were in a given neighbourhood.[49]

Evidently, these studies show that SES is strongly associated with the amount of air pollution exposure in a given neighbourhood.[50] Understanding this connection is key to linking lower SES individuals with higher risk of respiratory disease. As previously discussed, air pollution has made extraordinary impacts on human respiratory health. Therefore, lower SES individuals would be exposed to polluted air more often and, in turn, carry a higher risk of experiencing respiratory complications during their lifetime.

4. EFFICACY OF CURRENT EFFORTS AGAINST AIR POLLUTION AND ITS ASSOCIATED RESPIRATORY CONDITIONS

4.1 POLICIES

National climate policies may be ineffective in lowering consumption-based CO_2 emissions (carbon footprints) in a world with varying emission reduction objectives.[51] For instance, reducing carbon emissions is a lower priority in China where economic growth is primarily based on industrial processes for manufacturing of goods.[52] In this case, efforts to reduce carbon emissions could have a direct impact on economic prosperity which is why it is not as emphasized.[53] In other countries, such as Denmark, whose economy is less dependent on industrial processes, carbon reduction efforts are more prominent.[54] Additionally, Denmark has a high GDP allowing it to withstand an economic reconstruction away from the consumption of fossil fuels.[55,56] A study looked at whether well-designed policies could reduce global material, energy use, and carbon emissions while having minor effects on living standards.[57] They assessed global decoupling potential using a novel combined economic and environmental modeling approach. This novel approach entails production (territorial) and consumption methods to examine regional differences in natural resource use and carbon emissions across three stylized policy outlooks.[57] A reference case with no significant changes to the environment and climate policies consisted of a high efficiency outlook with a global carbon price rising from US$50 to US$236 per tonne of CO_2 between 2010 and 2050, and improvements in resource efficiency (rising from 1.5 percent historically).[57] The authors discovered that the amount of carbon emissions would be less than half of the reference case with a global carbon price, and material use would grow at a slower rate. Organization for Economic Co-operation and Development (OECD) economies have significant potential to reduce material throughput and carbon emissions while maintaining economic growth.[57] In contrast, developing economies, such as China, could expand their economies at a much lower environmental cost. Globally, very strong reduction and resource efficiency policies have negligible effects on economic growth and employment until 2050.[57] According to the 2016 study, decarbonization and dematerialization are possible with well-designed policy settings and would not conflict with efforts to improve human well-being and living standards.[57]

An investigation of the National Policies for Effectiveness of Carbon Emission Reductions in International Supply Chains found that in the case of building construction, adding a carbon tax is highly effective in reducing consumption-based emissions.[51] In contrast, due to reallocated investment capital, an information obligation on vacant dwellings combined with a penalty payment if vacant buildings are not made available is ineffective.[51]

Another study concluded that since 2015, the once-dominant theme has now proceeded backwards: maintaining, if not growing, support for fossil-fuel extraction and burning while decreasing support for cleaner alternatives.[58] Although the consequences of these measures have yet to be quantified, it is plausible to infer that they will result in increased carbon emissions and subsequent consequences on respiratory health.

4.2 GREEN-SPACE DESIGN IN URBAN MUNICIPALITIES

Another measure taken to combat air pollution and its adverse effects on human health is the introduction of public green spaces – understood as outdoor grounded vegetation – in cities. Green spaces and vegetation have been proven to reduce concentrations of air pollution, with a greater effect on particulate matter.[59] A study conducted by Selmi et al. in Strasbourg from 2012-2013 calculated that public trees remove approximately 7% of emitted PM_{10} from the atmosphere, with effects on other air pollutants being small.[60]

Research has also indicated that urban green space has a significant effect in the reduction of mortality of respiratory diseases and conditions. A study conducted by Jaafari et al. (2020) in Tehran applied equation modeling and metrics to predict and evaluate the effects of green space on health.[61] This study found that the most important variable when considering urban green space was its area, and that maximizing urban green space (and its cohesion) contributed not only to a reduction of air pollution, but also the mortality of Tehranian citizens.[61]

It was suggested that trees and public green spaces are methods of reducing air pollution, but more work is necessary to reap the full benefits of these methods. Urban planning strategies, such as the location of local sources of pollution, street design, traffic management, built structures, as well as other factors must also be carefully monitored.[60] Additionally, the density of tree groupings, gender of trees, and other variables must be considered to reduce the incidence of allergens and trapped pollutants that can be dispersed by air currents.[62] Urban green space implementation can yield beneficial results, but in order to avoid negative health impacts, more research must be done to understand its limits.

5. LIMITATIONS AND NEXT STEPS

While our paper can provide valuable insight for the medical and urban planning fields of the future, it is important to acknowledge that limitations do exist. Many studies mentioned throughout our paper showcase strong associations between air pollution and respiratory disease as well as air pollution and SES. While this can provide context on relationships between variables, they remain strictly correlational. More research is warranted in these areas to determine whether these connections exist and are causal.

Our review analyzes studies from all over the world. However, we recognize that we did not present data from every region. Therefore, our findings should be approached with caution due to the potential of lacking generalizability for regions not mentioned.

In the future, there should be more systematic reviews conducted to assess the situation on a global scale with a more comprehensive overview of different countries. In addition, a larger set of socioeconomic variables should be assessed in future studies, including immigration status, race, gender inequalities, and more. Such studies would also benefit from incorporating direct responses from underprivileged and discriminated groups to better understand the situation from the perspective of those affected.

5. CONCLUSION

Ultimately, this review comprehensively summarizes the impact of air pollution on the respiratory system, comments on the efficacy of efforts being done to tackle the problem, and introduces how socioeconomic variables come into play. This review sets a good starting point for others to further research the topic while thoroughly becoming acquainted with the respiratory impacts of air pollution.

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APPENDIX: SEARCH STRATEGY

To ensure an optimal method of scoping research, we conducted systematic literature searches on Google Scholar and PubMed with five key terms: "human health", "impact of air pollution", "respiratory health", "socioeconomic factors", "public health". Each author individually compiled a list of articles to select the ones most relevant to the research question. Collectively, overlapping articles were selected for analysis.

The inclusion criteria consisted of any primary research study article in English that mentioned air pollution's impact on human respiratory health and/or the socioeconomic factors which affect their exposure to air pollution. The exclusion criteria were any study that analyzed participants who were of 18 years or younger of age. Secondary research was also used as well to supplement the topic; however, it was limited to less than three articles.

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