Examination of Air Pollution's Relationship with COVID-19, Physical and Mental Health

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ABSTRACT

Air pollution is a result of natural phenomena or human activities that can cause the release of harmful substances in the environment, leading to adverse health outcomes among living beings. Pollution is associated with adverse health impacts on multiple organ systems among humans. While the respiratory and cardiovascular systems are mainly affected, there are other health issues related to the eyes, skin, brain, blood, immunity, behavioral/mental well-being, and reproduction among exposed individuals. Air pollutants can especially have higher health impacts on people at the extremes of their ages (children and elderly) and on those suffering from underlying respiratory and heart issues. Pollutants such as ozone, sulfur dioxide, particulate matter, and nitrogen dioxide have respiratory effects among children and adults and are associated with increased respiratory diseases, asthma exacerbations, and related hospitalizations. Carbon monoxide interferes with transporting oxygen by forming carboxyhemoglobin leading to cardiovascular, neurological, and respiratory problems. Particulate matter is a heterogeneous mixture of tiny particles of varying compositions found in the atmosphere and has a wide variety of severe health effects. Particulate matter emits from combustion, diesel engines, power generation, and wood-burning, and certain industrial activities. Lead is considered neurotoxic and has more severe consequences among children. Here we summarize characteristics of six criteria air pollutants and associated air quality risk assessment parameters known as the Pollutant Standard Index (PSI). The present manuscript also examines the impact of air pollution on human behavior, mental well-being, and neurological health consequences, as air pollution has been associated with cognitive decline, hyperactivity, dementia, anxiety, depression, aggression, and Alzheimer's disease-related changes. Lastly, we also attempt to look into any relationship between air pollutants and Coronavirus disease (COVID-19) and examine its possible association with a higher COVID-19 incidence, complications, and mortality.

Keywords: particulate air pollution, adverse health effects, human health, COVID-19, environmental health, Pollutant Standard Index

BACKGROUND

Air pollution is the presence of harmful substances due to natural phenomena or anthropogenic activities in the environment that can have detrimental health consequences on humans when exposed.^{1,2} Air pollution is categorized into outdoor (ambient) and indoor types.^{1,2} According to the World Health Organization (WHO), 9 out of 10 individuals are inhaling polluted air, which results in millions of deaths each year.² Here we explore the impacts of air pollution on human behavior, mental well-being, and neurological health consequences while summarizing characteristics of six criteria air pollutants and associated parameters known as the Pollutant Standard Index (PSI). Furthermore, we also attempt to look into any relationship between air pollutants and Coronavirus disease (COVID-19).

TYPES, MECHANISM, AND COMMON HEALTH IMPACTS

There is already clear proof that both short- and long-term ambient air quality changes are correlated with elevated mortality and morbidity among adults and children.^{3,4} Six air pollutants including carbon monoxide, sulfur dioxide, lead, particulate matter, ozone, and nitrogen oxides (nitric oxide and nitrogen dioxide) all are associated with adverse health occurrence among exposed individuals (Table 1).⁵⁻⁸ The PSI is a generally used risk assessment parameter derived from the ambient concentration of the major air pollutants.⁹ The PSI can be used to assess air pollution levels from 0 to 500, values above 100 being considered unhealthy.⁹

In household settings or indoors, air pollution is associated with fuel combustion (appliances, heating, stove etc.), tobacco use, building materials, household cleaning chemicals, heating/cooling systems, and pesticides.¹⁰ Inadequate ventilation or movement of outdoor pollutants into indoor spaces can further deteriorate air quality.¹⁰ Indoor (household) pollution has been linked to higher lung cancer risk, especially when houses are not well ventilated, coal is used for household activities, and the residence is located near industrial areas.¹¹⁻¹³ In outdoor settings, the pollutants can negatively influence cardiovascular, neurological, and respiratory health. Particulate matter (PM), which is a complex mixture of diverse particles (sulfate, ammonia, carbon, mineral dust, nitrate compounds), has been associated with morbidity and mortality related to respiratory and cardiovascular illness.^{14,15} Sulfur dioxide and ozone both act as respiratory irritants and can trigger or deteriorate asthma and other respiratory conditions.^{15,16}

Nitrogen dioxide has also been associated with respiratory conditions such as asthma, bronchitis, increased susceptibility of lung infections, and wheezing.^{15,17} Lead exists naturally or through the burning of fossil fuel, industries, and mining, and it is associated with neurological and renal problems amongst exposed individuals. Children are more vulnerable to the effects of lead.² It is evident from studies that air pollution has negative impacts on infants' and children's health and is linked with preterm birth, lung developmental/functional issues, and overall increased morbidity and mortality.¹⁸⁻²¹ Since the lung tissue is still in development and over 80% of alveolar growth occurs after birth, infants are more susceptible to air pollution and environmental toxins.²²⁻²⁴ In time-series studies conducted in cities with notoriously high levels of pollution, such as Mexico City, Seoul, and Sao Paulo, associations between particulate matter $\leq 10 \mu\text{m}$ (PM10) and infant mortality have been found.²⁵⁻²⁷ Spatial similarities within the Czech Republic and the US have been reported between post-neonatal mortality and atmospheric particulate matter.^{28,29}

HUMAN BEHAVIOR, MENTAL HEALTH, AND NEUROLOGICAL DISORDERS

The effect of noise, heat, and air pollution on human behavior, specifically aggression, has been documented. Although the respiratory and cardiovascular impacts of air pollution are well known, recent research shows that it also contributes to behavioral, psychological, and neurological issues. The mechanism of this is not precise. However, tiny pollution particles can reach the brain directly from nasal passages.^{30,31} Furthermore, particles can also reach the brain after being absorbed in the blood through the alveoli.³¹ Once these pollution particles reach the brain cells, they induce an inflammatory response that could lead to neurodegeneration.³¹ The consequences of high and long-term exposure are seen in forms of cognitive decline, especially among children, causing hyperactivity, dementia, anxiety, depression, aggression, and can even predispose to Alzheimer's disease.^{30,31} In one Chinese study, a high level of air pollution was associated with an increase in sedentary behavior, leading to other health issues.³² In a UK-based study, reduced indoor and outdoor air quality significantly affected emotional and behavioral problems related to conduct/temper and hyperactivity among children.³³ Similar outcomes were noticed in a Californian study in which long-term exposure of PM2.5 possibly increased delinquent behavior among adolescents and teenagers.³⁴ Exposure to lead is known to cause harmful effects on the nervous tissue. Studies have shown that not

TABLE 1. Six criteria air pollutants

	Source	Characteristics	Health impacts (e.g. on organ systems)
Carbon Monoxide (CO)	outdoor (vehicles, burning fossil fuel), indoor air (gas heaters, stove, furnaces)	no odor, color, taste or irritation	cardiovascular, neurological, respiratory
Lead (Pb)	earth crust, burning fuel, mining, industries	bluish grey metal	neurological, renal, probable carcinogen
Nitrogen Oxides (NO & NO ₂)	motor emission, burning of oil or coal, industries	non-flammable, colorless to brown	respiratory
Ozone (O ₃)	motor emission, industries (boilers, chemicals)	main ingredient in smog	benefits: stratospheric ozone protects from UV radiation, harmful (ground level): respiratory
Sulfur Dioxide (SO ₂)	coal and oil burning, volcanic eruptions	colorless, pungent	respiratory
Particulate Matter (PM)	chemical reactions between pollutants	mixture of solid and liquid particles, PM10: diameter ≤10 µm, PM2.5: diameter ≤2.5 µm (both PM10 and PM2.5 are inhalable)	respiratory, heart

only lead is associated with a decline in cognition, intellect, and memory among children and adolescents, but if exposure occurs at a young age and continuously, it can result in personality and behavioral issues in adulthood.^{35,36} The literature also suggests lead exposure involvement in Parkinson's disease.³⁷ As per some research studies, smoking, which contributes to environmental air pollution, can increase the risk of Parkinson's, although other studies state the opposite.³⁷ Also, both active and passive smoking is linked with the etiology of multiple sclerosis.³⁸

AIR POLLUTION AND COVID-19

As mentioned earlier, the long-term exposure to pollution has been connected to morbidity and mortality associated with respiratory inflammation, chronic lung disease, asthma, and cardiovascular disorders. A study examining data from over 3,000 US counties shows that in areas with slightly higher levels of PM2.5 (i.e., 1 µg/m³), there was an 8% increase in COVID-19-related deaths.³⁹ Historically, this kind of relationship was also seen in a 2003 Chinese study where both short- and long-term exposure to air pollution was positively associated with severe acute respiratory syndrome (SARS)-related mortality.⁴⁰ Air pollution can also increase the incidence of COVID-19 as examined in a recent Chinese study where short-term exposure to O₃, PM (2.5 & 10), and NO₂ was significantly associated with higher numbers of COVID-19 cases.⁴¹ Further studies are needed to explore the role of the PSI or air pollution indices, individual and combined effects of air pollutants on COVID-19 incidence, disease course, and mortality. Hypothesis testing based on the dose-response relation-

ships, temporal trends, exposure inequality by geography, and monthly/yearly variation of air pollution on COVID-19 could provide crucial information about the dynamics and management of COVID-19 infection. More studies are needed to examine the interrelationship between the COVID-19 disease process and air pollutants. To examine this vital relationship, diverse and enhanced surveillance approaches coupled with multidisciplinary and mixed-method research studies can be crucial.^{42,43}

SUMMARY & CONCLUSIONS

Environmental toxins and hazards have adverse impacts on humans throughout their lifespan. For instance, exposures during pregnancy can result in developmental issues, birth defects, intellectual delays, and cancers. After birth, while growing, they are more susceptible to air pollution and other toxins as their organs are still in developmental phases. Although all age groups are vulnerable to the effects of air pollution, the impacts are higher among people of extreme ages. The present short review examines the impact of air pollutants on humans and particularly explores associated mental health outcomes. The persistent exposure of pollutants can cause impairment of different organ systems. We also see that mortality is higher in places where air pollution is a significant issue. Furthermore, early studies are showing unfavorable COVID-19-related outcomes in the presence of high levels of air pollutants. More research is needed to examine the interrelationship between the COVID-19 disease process and air pollutants, with the use of multidisciplinary research studies. Rapid industrialization, increased use of cars, buses, and airplanes during the last

and current centuries have contributed to public health issues related to air pollution. It is known that the use of motor vehicles can contribute largely to the pollution in a geographical area; hence, changes in transportation mode (e.g., reduced use of cars, increased use of bicycles, electric vehicles, or mass public transportation etc.) can help in reducing this problem. City planning, opportunities to provide easy access to the public transportation systems, increase in vegetation, and plantation of trees can also contribute.

CONFLICT OF INTEREST

None declared.

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