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POINT OF VIEW

COVID-19 and air pollution: A dangerous association?

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Abstract In late 2019, a new infectious disease (COVID-19) was identified in Wuhan, China, which has now turned into a global pandemic. Countries around the world have implemented some type of blockade to lessen their infection and mitigate it. The blockade due to COVID-19 has drastic effects on the social and economic fronts. However, recent data released by the National Aeronautics and Space Administration (NASA), European Space Agency (ESA), Copernicus Sentinel-5P Tropomi Instrument and Center for Research on Energy and Clean Air (CREA) indicate that the pollution in some of the epicenters of COVID-19, such as Wuhan, Italy, Spain, USA, and Brazil, reduced by up to 30%. This study compiled the environmental data released by these centers and discussed the impact of the COVID-19 pandemic on environmental pollution.

Introduction

In December 2019, the first cases of a new disease of unknown origin were identified in Wuhan, capital of Hubei province, China. The pathogen involved was named Coronavirus 2 or SARS-CoV-2 *(Severe acute respiratory syndrome coronavirus* 2) responsible for COVID-19 (*Coronavirus disease 19*).[1]

The rapidity and global reach of COVID-19 have made the World Health Organization (WHO) define the disease as a public health emergency of international interest.[2] Urgent questions were raised that required coordinated and certified information from public healthcare systems to delay its devastating power and identify the primary modifiable environmental factors that could increase the severity of health outcomes (age, hospitalization, intensive care unit, mortality) among individuals with COVID-19.[1,3,4]

More than 297,000 people have died, and more than 4.6 million have fallen ill.[5] However, for those who have not been contaminated, the disease has caused significant changes to their lifestyle. COVID-19 also caused some unexpected consequences, such as the closure of industries, trade of non-essential items, transportation networks, and companies, accompanied by drastic declines in environmen-

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tal pollution as governments introduced strict restrictions to combat the novel coronavirus pandemic.[6]

Air pollution is known to cause damage to many organs and body systems, especially the respiratory and cardiovascular systems, being responsible for 4.2 million deaths (7.6% of total global deaths) in 2015.[7] A particularly extensive and dangerous encounter with the virus must be feared if air pollution is an important factor in determining the extent and lethality of COVID-19 in highly polluted areas around the world.[8]

Atmospheric concentrations of particulate matter (PM) with a diameter of 2.5 μ ($PM_{2.5}$) dropped substantially in much of China during the pandemic, but not evenly. Monitoring of satellite pollution from the *National Aeronautics and Space Administration* (NASA) and the European Space Agency,[6] found that in cities in northern China, such as Beijing, where much of the pollution comes from heating during the winter, there have been no reductions. However, in southern cities such as Shanghai and Wuhan where there is heavy industrialization and intense air pollution, the decline in pollution was very substantial. The decline demonstrated a clear correlation of COVID-19 infestation[9] in China with levels of pollution and local climatic conditions with a low temperature, moderate daytime temperature range, and low humidity that would favor the transmission of the virus.[10]

Declining levels of pollution have also been noted in northern Italy, coinciding with the national lockdown to prevent the spread of the novel coronavirus, which resulted in less traffic and industrial activity. A recent study identified correlations between COVID-19 mortality in northern Italy, including Lombardy, Veneto, and Emilia-Romagna, and the high levels of pollutants in those regions.[11] This decrease in environmental pollution was also seen in Barcelona, Spain, after two weeks of lockdown due to the novel coronavirus pandemic.[12]

It is known that the transmission of SARS-CoV-2 by aerosol and fomites is plausible, and the virus can remain viable and infectious in aerosols for hours and on surfaces for days.[13] Setti et al.[14] suggest that PM could act as a carrier for droplet nuclei, boosting the spread of the virus. The results were corroborated by Coccia et al.[15] who demonstrated that the accelerated transmission dynamics of COVID-19 resulted mainly from transmission by contaminated air to man, besides the transmission from man to man.

The exhaled droplets would be stabilized in the air from the aerosol fusing with the PM in highly concentrated stable conditions. Under normal conditions with clean air and atmospheric agitation, a small droplet meets with the virus and evaporates or disperses rapidly in the atmosphere. On the contrary, in a stable atmosphere with high concentrations of PM, viruses have a high probability of agglomerating with the particles and reducing their diffusion coefficient, increasing their amount of time and permanence in the atmosphere, and becoming more contagious.[14]

In England, Travaglio et al.[16] provided further evidence of the relationship between air pollution and SARS-CoV-2 lethality by showing an association between pollutants released by fossil fuels and susceptibility to viral infection. This association suggests that individuals exposed to chronic high levels of air pollution may be more susceptible to SARS-CoV-2 infection. This would occur as a result of compromised immune defense responses due to pollution, as has already been demonstrated in patients affected by severe viral pneumonia during other pandemics.[17,18] Recent studies suggest that the cause of death of many COVID-19 patients would be related to cytokine storm syndrome, a severe reaction of the immune system that leads to a chain of destructive processes in the body that can end in death.[19]

Similar trends were observed in other regions of Europe, such as France, where COVID-19 distribution maps depict areas with a very large number of severely infected patients requiring hospitalization. This trend was seen in Paris, Lyon, and Toulouse and regions like the Belgian-Swiss border near Lyon and the coast from Nice to Montpellier, where there is a significant problem with air pollution and large agglomerations.[20]

This has also been proven in the Czech Republic where the intense pollution in Prague and the highly industrialized eastern regions of the country is strongly correlated with the number of people who have been diagnosed with COVID-19.[20]

In Poland, when comparing polluted areas and the total number of novel coronavirus infections in each province, there was again a very high agreement. The province of Mazovia led in the number of COVID-19 cases with Upper Silesia taking second place. In all of these areas, the mean PM value fluctuated from 19.58 $\mu g/m^3$ to 29.84 $\mu g/m^3$ (daily allowable $PM_{2.5}$ concentrations =25 $\mu g/m^3$).[20]

In the United States, a recent study investigated the average long-term exposure to $PM_{2.5}$ and the risk of death from COVID-19. It has been shown that an increase of just 1 $\mu g/m^3$ in $PM_{2.5}$ is associated with a 15% increase in the COVID-19 mortality rate, (95%CI: 5% to 25%), with a magnitude 20 times greater than that observed for $PM_{2.5}$ and mortality from all other causes, suggesting that long-term exposure to air pollution increases the vulnerability to the occurrence of more severe results from COVID-19.[21]

Although the transmission of the disease beyond Asia was initially focused on Western Europe and North America, there has been a significant expansion to other parts of the world, including many Latin American countries.[22]

One area of great concern is Brazil, where more than 160,000 cases and more than 11,000 deaths have been reported. The distribution of deaths among states is highly heterogeneous, with five states – São Paulo, Rio de Janeiro, Ceará, Pernambuco, and Amazonas – accounting for 81% of the reported deaths.[23]

State and municipal authorities have undertaken extensive public health measures to reduce the transmission of COVID-19 in response to the virus being significantly spread and transmitted by impoverished Brazilian neighborhoods. The authorities have declared a state of emergency, closed retail and service businesses, restricted public transportation, and closed schools.[22]

According to images captured from the S-5P satellite, we can see that the atmospheric pollution has significantly decreased in these metropolitan areas during quarantine due to the COVID-19 pandemic.[23]

According to data from the NASA satellite, when analyzing the Brazilian regions with the highest index of infected individuals, hospitalization rates, and mortality due to COVID-19, we find that the effects of isolation resulting from the pandemic led to significant reductions in pollution levels.[23]

During the partial shutdown in the city of São Paulo, four air quality measuring stations showed the urban area to have drastic reductions in concentrations of NO (up to 77.3%), NO_2 (up to 54.3%), and CO (up to 64.8%) as compared to the five-year monthly average.[24]

The impact of the partial shutdown on the city of Rio de Janeiro's air quality showed a significant reduction in CO levels (30.3% to 48.5%) and NO_2. PM_{10} was reduced just in the first week of the shutdown,[25] similar results to those observed in China, Italy, Spain, and other areas of the world.[10-12,16,21]

In Pernambuco, data provided by the Environmental Institute of Santa Catarina (IMA-SC) and by the State Secretary of Environment and Sustainability (SEMAS), affirmed that restrictive measures against the novel coronavirus contributed to a considerable decrease in the emission of gaseous pollutants in Pernambuco.[23]

During the period of social isolation and the closing of trade, researchers from the State University of Ceará (UECE), pointed out that there was a 50% reduction of O_3 levels in the air in Fortaleza. In Brasilia, IMA-SC satellite images show a clear reduction of NO_2 traces resulting from the decrease in the number of people traveling to Brasilia during the pandemic.[23]

The air pollution levels have also been drastically reduced in the state of Minas Gerais, especially in the city of Belo Horizonte. There was less of an influence of vehicle emissions at the PUC Minas São Gabriel Station, considering the $PM_{2.5}$ (breathable particulates) and NO_2 pollutants.[23]

Researchers estimated that the population of the southwestern Amazon had high exposure to air pollutants. This estimate was based on data from 30 air-quality monitoring sensors installed in 22 municipalities in the state of Acre from June to December 2019. These results reinforce the hypothesis that the regional health system may be depleted when compounding the crisis installed by the COVID-19 pandemic with the already observed increase in fires and deforestation and the high atmospheric pollution of this region.[23]

Recently, the Centre for Research on Energy and Clean Air (CREA) presented a report highlighting that measures to combat the novel coronavirus led to a reduction of approximately 40% in the average levels of NO_2 and 10% in the average PM levels in the last 30 days, resulting in 11,000 deaths avoided by air pollution (95% CI: 7000– 21,000).[26]

The final CREA report on the links between COVID-19 and air pollution concluded that:[26]

- High levels of air pollution affect the body's natural defenses against airborne viruses, increasing the likelihood that people will contract viral diseases, and this is also possible with SARS-CoV-2.
- Exposure to air pollution is an essential risk factor for many of the chronic diseases that make people more likely to become seriously ill, require intensive care, mechanical ventilation, and die from COVID-19.
- Exposure to air pollution can worsen the symptoms of individuals with respiratory infections and increase the risk of hospitalization and death. Despite reductions caused by control measures taken against spreading the virus, current levels of air pollution, which remain dangerous in much of the world, are likely contributing to the number of severe cases of and deaths by COVID-19.

Naturally, forces will focus on emergency response planning during the COVID-19 pandemic. These forces include containment, vaccine treatment and development, declines in the economic well-being of families, or the difficulty of accessing health services. However, an emergency can also open a window of opportunity to reflect and learn.[27]

We need a planetary health perspective that embraces the traditional domains of the knowledge, governance, and economy sectors to adequately address the challenge presented by COVID-19[28,29] to identify and prevent future events in the broader context of the Sustainable Development Goals.[30]

In conclusion, what would we ask ourselves about, and what lessons can be learned from the pandemic and applied to the climate crisis? Pandemics like COVID-19 will return, most of them linked to the collapse of the environment. We need good strategies to fight the virus, and, in the future, we need adequate preventive measures, and the main one is to clean the air we breathe.

Solving the climate crisis requires broad acceptance of systemic changes. For this to happen, people need to want to move towards a more sustainable society and economy, without which the transformation will not be maintained. Unfortunately, far from showing that it is possible to face the climate crisis, COVID-19 can demonstrate how difficult it will be if we ignore the main point: the sooner societies start to adapt and reduce carbon emissions, the less they will suffer.

Conflict of interest

The authors have no conflict of interest to declare.

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