

AN OVERVIEW: THE EFFECTS OF PARTICULATE MATTERS, AN IMPORTANT ATMOSPHERIC POLLUTANT, ON THE SPREAD OF COVID19

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Abstract

Introduction: This review deals with research and scientific perspectives about whether there is any effect linked to particle size and structure of one of the significant atmospheric pollutants of particulate matter (pm) on the duration of residence in air and transport of the virus causing Covid19, originating in China and becoming a global pandemic in 2020, and hence whether pm may change the level of effectiveness of the virus in humans. **Discussion:** The virus causing Covid19 may bind (adsorption) to the surface of particles classified as fine particles and use these particles as transporters. These may easily pass into the throat and lungs of people via inhalation and cause deadly disease, as revealed by the results of scientific research. Fine particles may display variability in terms of chemical properties, emission density, degradation duration, and long- and short-distance transport properties, in addition to precipitation or suspension mechanisms. **Conclusion:** In this study, a review was prepared by investigating research performed since 2020 about the correlations between the virus causing Covid19, continuing to have deadly effects worldwide, with pm density and particle diameter to provide a guide for future studies.

INTRODUCTION

Air pollution is characterized as the presence of one or more pollutants in the outdoors, i.e., in the atmosphere, in quantities and periods enough to affect the human, plant, and animal life, commercial or personal belongings, and environmental quality. Air pollutants causing air pollution can be subjected to a general classification based on their formation sources, whether they are animate or not, and their chemical structures.

Based on their source of formation, air pollutants are divided into two main classes as primary and secondary pollutants. Primary pollutants that are directly emitted to the atmosphere are divided into two sub-classes, namely, the gases (SO_2 - SO_x , NO_x - NH_3 , CO_2 - CH_4 , and VOC) and particulate matter (pm)s-(primary particulate matter). The secondary pollutants formed due to the reaction of primary air pollutants in each other. The O_3 , SO_3 , HNO_3 , H_2SO_4 , H_2O_2 , NH_4 those particles are called secondary particulate matter. Besides, air pollutions, namely photochemical smog and acid precipitation, are known as secondary pollutants.

On the other hand, we can generally classify the animate particles like bacteria, fungi, yeasts, algae, and vegetable origin (vegetable secretions). All particles other than these may be considered inanimate. We can divide these pollutants into two main classes: gases and PMs for classification based on chemical structures. We can classify the gases as organic and inorganic gases. The PMs, we can classify as; mist or fog, which is "quite small water globes in the air"; fume, which is "particles formed as after the condensation of inorganic and organic vapors in the air"; dust which is the "smaller particles as primarily the result of large solids breaking down"; smoke which is "black particles formed after burning" (1).

After making a general classification of air pollutants, we can detail the PMs as follow: PMs can be defined as fine particles originating from natural sources and anthropogenic origin activities or fine solids dispersed in a gas.

Natural sources of PMs include volcanic activity, marine aerosols and salts, wind-blown soil particles, fires, desert sands, organic matter, and microorganisms. Anthropogenic resources, on the other hand, include the dust emerging from the activities of cement factories, thermal power plants, metal industries, and construction works, mining activities, vehicles; the fly ashes formed as a result of burning coal and petroleum derivatives, and lastly, the particles dispersed into the atmosphere during agricultural activities. Among these resources, particularly those with anthropogenic origins, generally

have small particle sizes and are deemed more harmful to human health (1).

We can subject PMs to a new ranking in terms of aerodynamic diameters as PM_1 - $\text{PM}_{2.5}$ - PM_5 - PM_{10} within themselves. Concerning the aerodynamic diameters, particles with diameters 10-2.5 μm are called coarse particles, while the ones with $\text{PM} \leq 2.5 \mu\text{m}$ are called fine particles, and particles with $\text{PM} \leq 0.1 \mu\text{m}$ are named ultrafine particles. While the coarse particles of pm_{10} and above are mainly formed after mechanical processes, fine particles, on the other hand, are formed as a result of exhaust gases and photochemical activities. Particles smaller than 0.1 μm act like molecules, and they are in random movement constantly.

Regardless of their size, particles sooner or later return to the earth through wet and dry deposition mechanisms. Particles returning to the earth's surface due to gravity are named sedimentation. When particles collide in the air, they may come together to form larger particles. This mechanism is called coagulation. Because of their increased density, coagulated particles return to earth more easily.

PMs, which are among the pollutants in the atmosphere, trigger plenty of environmental issues. PMs are extremely harmful to houses, properties, soil, plants, and humans.

If we examine the detrimental effects of PMs in the air on human health, we can suggest those effects have a linear relationship with particle size. While $\text{PM} \geq 10 \mu\text{m}$ particles can adsorb the nasal and upper respiratory tracts, $\text{PM} \leq 2.5 \mu\text{m}$ particles can accumulate in the lung bronchi. In addition to their ability to adsorb or absorb heavy metals such as mercury, lead, cadmium, and carcinogenic chemicals in their bodies, these PMs, toxic-carcinogenic chemicals, can pose significant health risks by integrating with the air humidity and the moisture in the upper respiratory tract (2).

There is a similar and quantitative correlation between mortality and exposure to PMs, including small particle sizes at high concentrations. On the contrary, it has been determined that in settings where the concentrations of small and fine particles decrease and other factors remain the same, corresponding mortality rates decrease. Small particle pollution, on the other hand, poses serious health problems even at minimum concentrations. Several studies have shown that as particle size decreases, so do the harmful effects on respiration and the lungs diminish (2).

It is known that the Covid19 virus can be transmitted from person to person indoors with the help

of bioaerosols through respiration. Pollutants in the ambient air and the atmosphere are similar. Moreover, indoor particle number and mass concentration are mainly influenced by outdoor sources (3).

Similarly, numerous studies have shown that high levels of air pollution (gas-pm) increase the airborne transmission of viruses that can cause a wide range of diseases (4-9). Many studies have shown that as particle size decreases from fine to ultra-fine, the surface area increases, culminating in a substantial increase in the adsorption capacity of viruses to the surface. Furthermore, an increase in the remaining time-span of viruses adsorbed on the surface of particle materials in the air (10-12). In combination with specific climatic conditions, air pollutants can contribute to a more extended stay of the virus in the air and support coronavirus diffusion's short-term effect. Air may be the vehicle through which microbial agents move in the environment before being inhaled. PMs contain microscopic solids or liquid droplets that are small enough to be inhaled and cause serious health problems. Microorganisms (especially those smaller than 2.5 microns) that reach the lungs associated with PM₁₀ and PM_{2.5} are inhaled, allowing the virus to cause infections (13-14).

Viruses have an aerodynamic diameter about ten times that of bacteria, so the number of viruses per unit area is ten times greater than the number of bacteria, and PMs per unit area is about ten times more likely to be adsorbed to or stuck in the surface.

As is known to all, the Covid19 virus, which first appeared in Wuhan, China, near the end of 2019 and quickly spread to several populations, first in China and then worldwide, is one of the most significant and deadly pandemics in recent years (15). The virus, which has spread to many countries in the world quickly, fatally affects human health.

Research has revealed that the Covid19 virus (like other viruses) spreads by adsorption to particles suspended in the air, thus increases airborne transmission ability, and the virus particularly adsorbs to the PM_{2.5} and smaller particles (fine-ultrafine) and remains as animate in aerosols for hours; hence, it can be transmitted to humans more easily. To manage and avert this new problem caused by the coronavirus and the resulting deadly pandemic, it is necessary to properly investigate the relationship of the virus with the diameter and concentrations of PMs in-depth and reveal new findings on the issue.

Different researcher groups have been looking into the relationships between coronavirus, PMs

concentration, and PMs diameter (increase in the capacity of viruses to be transmitted by air, the duration of virus suspension in the air, and the adsorption mechanisms of viruses to the surface) since 2020 and this studies are continuing uninterruptedly. In terms of guiding future studies, reliable results arising from subsequent studies are critical.

The effects of PMs on the period and transmission of the Covid19 virus in the air, specifically focusing on particle size and chemical structure, are explained in this review, and the information that the virus can modify its capacity to impact humans health is summarized from a scientific standpoint.

DISCUSSION

Long-term inhalation of polluted air with gas and PM in cities is known to cause significant health problems (respiratory disorders and chronic poisoning) concerning public and environmental health. The respiratory system/tract is examined in two parts: upper (mouth-nose-throat) and lower (lung). While coarse particles can be strained in the upper respiratory system (hairs and mucoid tissue in the nose), fine-ultra fine particles can get out of filters in the upper respiratory tract and easily reach the lung edges, and settle there without being captured by any obstacles. The smaller the particle size, the longer it can settle and remain in the lung. Apart from their acute toxic effects, particles that can linger in the depths of the lungs for years cause chronic severe toxic effects, particularly when coupled with the synergistic effects of other pollutants.

Scientific research performed showed that the Covid19 virus, similarly to this synergistic effect created by gases, also adsorbs to the surface of the particles that we classify as fine-ultrafine particles, uses the particles as transmission means, and can easily descend to the throat and lungs of humans via inhalation resulting in deadly diseases (16-17).

Since fine-ultrafine particles differ in chemical structure, emission density, disintegration times, long- or short-range transmission properties, precipitation or suspension mechanisms, their capacity to carry the Covid19 virus through various mechanisms may also differ. Although particulate matter concentrations can vary from one city to another, they can also vary within the same city. As a result, studies have revealed that the course and severity of the pandemic may vary in different parts of the same city (9,18).

The diameter and concentration of PMs have been shown a linear relationship between deaths and viruses in studies. There have been various

studies undertaken that demonstrate the correlation between $PM_{2.5}$ concentrations and Covid19 (12,19-26). Besides revealing the linear correlation between $PM_{2.5}$ concentrations and Covid19, related studies also investigated the effects of PM_{10} in detail (27). As clearly shown in Figure 1, there is a correlation between the measured $PM_{2.5}$ concentrations and PM_{10} concentrations, which implies that when PM_{10} reaches its peak concentration, $PM_{2.5}$ is also observed as dense. While studies founded upon this correlation examine the effect of particulate matter concentration on the incidence (density-frequency ratio) of Covid19, the combined effect of PM_{10} and $PM_{2.5}$ is also considered.

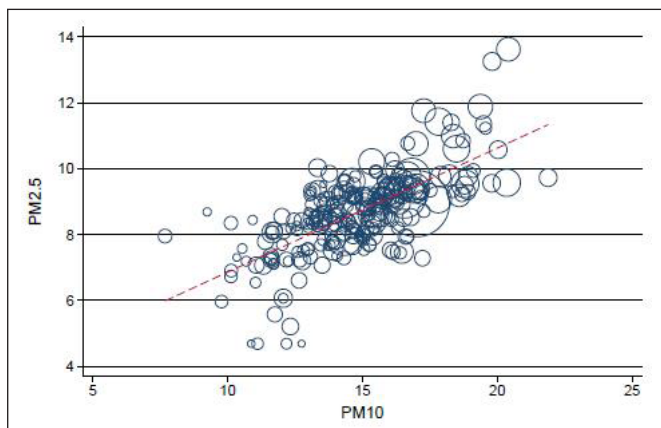


Figure 1. Correlation between $PM_{2.5}$ and PM_{10} (12)

Within the scope of a study conducted in Wuhan and XiaoGan cities of China where the pandemic has

started, especially the linear relationship between air pollutants of $PM_{2.5}$, PM_{10} , NO_2 and CO , and Covid19 virus has been examined in detail (23).

When the relationship of the $PM_{2.5}$ and PM_{10} between the virus spread is examined, the linear relationships of $PM_{2.5}$ concentration-Covid19 spread and PM_{10} concentration - Covid19 spread are clearly observed in Figure 2 (Wuhan city) and Figure 3 (XiaGan) (23).

Considering several studies investigating these pollutants together showed that $PM_{2.5}$ was slightly more effective than PM_{10} in transmission-spread of the virus. Covid19 mortality rates against $PM_{2.5}$ and PM_{10} have been examined and showed that $PM_{2.5}$ (p: 0.016) value was slightly higher than PM_{10} value (p: 0.014) is highlighted in the graph depicted in Figure 4 (25).

When looking at another study that is performed in 15 cities (shown in green) within Wuhan city of China (shown in red) and Hubei province, and 33 cities (shown in purple) outside Hubei province; the spatial relationships of daily $PM_{2.5}$ and PM_{10} concentrations with the Covid19 mortality rate were examined through the multiple linear regression method. It has been found that Covid19 causes higher mortality with the increasing $PM_{2.5}$ and PM_{10} concentration levels. Also, the results showed that $PM_{2.5}$ - PM_{10} concentrations might affect the healing process of patients with mild to severe disease (25).

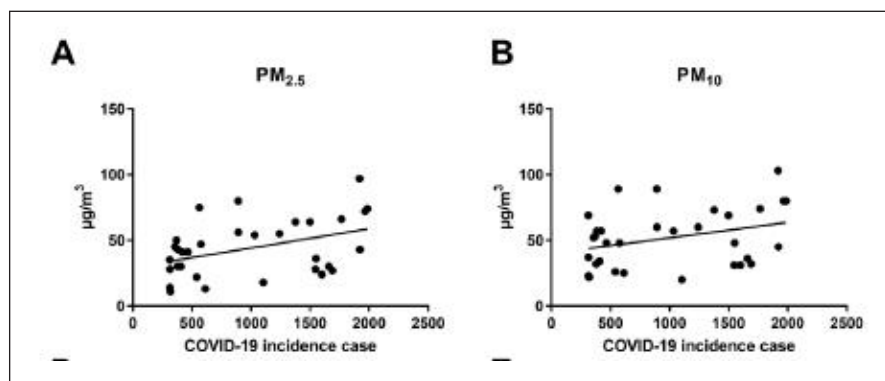


Figure 2. The Correlation between Daily Covid19 Incidence (Density-Frequency Ratio) in Wuhan and (a) $PM_{2.5}$ and (b) PM_{10} (23)

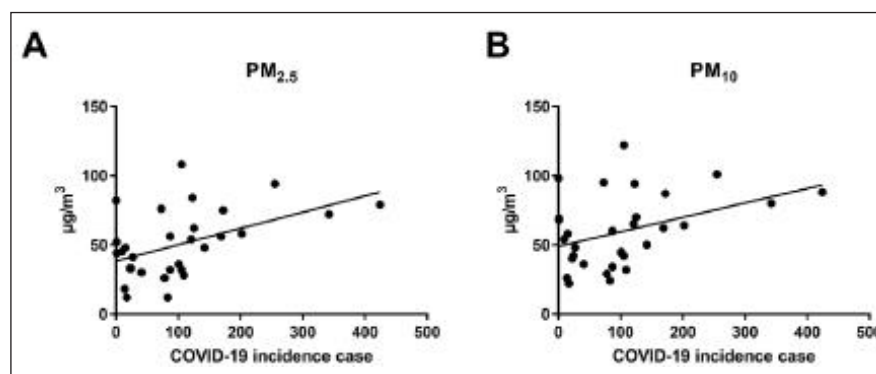


Figure 3. Correlation between Daily Covid19 Incidence (Density-Frequency Ratio) and (a) $PM_{2.5}$ and (b) PM_{10} in Xiaogan (23)

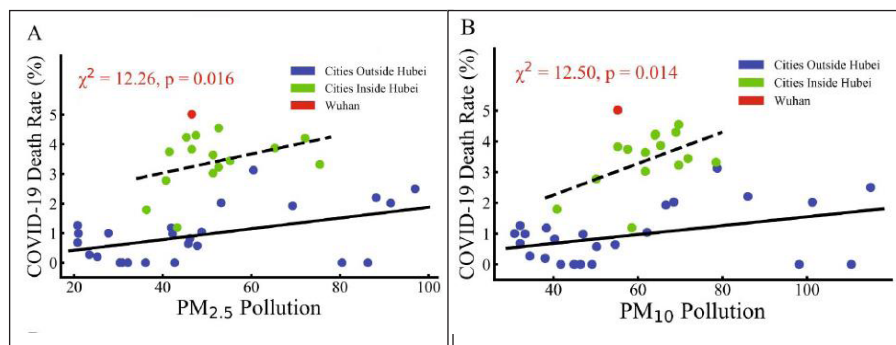


Figure 4. Covid19 Mortality Rates Against (a) $PM_{2.5}$ and (b) PM_{10} Pollution (25)

In another study conducted in China using data from 120 different cities between January 23 and February 29, 2020, the relationship between six air pollutants ($PM_{2.5}$, PM_{10} , SO_2 , CO , NO_2 , and O_3) and Covid19 have been studied in detail. It is seen that every $10 \mu g/m^3$ increase concentrations of $PM_{2.5}$ and PM_{10} causes a rise in the daily number of cases with ratios of 2.24% and 1.76%, respectively (9).

Another research looked at the impact of the spread of Covid-19 and explored the roles of $PM_{2.5}$, PM_{10} , and NO_2 in detail. This result has been emphasized that the contributions of $PM_{2.5}$ and NO_2 concentrations were higher than pm_{10} concentrations (17).

The correlation between the mortality and growing spread of Covid19 and air pollution was studied in a study performed in Milan, Italy. Firstly, it has been discovered that Covid19 is transmitted indoors through bio-aerosol droplets, surfaces, or direct contact between individuals and induces infection. High levels of urban air pollution, weather, and climate conditions escalated the spread of Covid19 and the total number of cases, the number of new cases per day, and the total deaths when we consider outdoors (16).

PMs are one of the most significant triggering environmental factors leading to the spread of Covid19, according to a study published in 2021 to protect environmental health and prevent the pandemic's spread. Data obtained from various countries have been revealed that $PM_{2.5}$ has a higher capacity to act as a risk factor than PM_{10} concerning the spread of Covid19 (28).

In addition to all these studies, epidemiological reports highlight an association between PM and Covid19; however, the underlying mechanisms remain unclear (29). A study have found the SARS-CoV-2 RNA on PM of Bergamo in Northern Italy (30-31). $PM_{2.5}$ can provide an excellent platform to "shade" and "transport" Covid19 during atmospheric transport. Therefore, $PM_{2.5}$ containing Covid19 can be a direct transmission pattern in highly polluted areas (32-35).

CONCLUSION

Many studies have supported the idea that high levels of air pollutants increase the airborne feature of viruses that cause various diseases. The correlation between PM and viruses, one of the major air pollutants, has been aptly illustrated in these studies. Viruses that have quite small particle sizes ($0.1 \mu m$) can be easily spread via horizontal or vertical positions by being adsorbed or absorbed into the surface of particulate matter ($PM_{2.5}$ - PM_{10}). It is also emphasized that the suspension period of viruses adsorbed to PMs in the air is prolonged, and the airborne transmission capacity of the virus has increased. It is well understood that as the particle aerodynamic diameter decreases, so does the capacity of viruses to adsorb to the surface. The relevant research results showed that the relationship between the $pm_{2.5}$ and Covid19 virus spread is stronger than particles with a diameter ≥ 10 - $2.5 \mu m$.

It has been reported that the Covid19 virus can be transmitted from individual to individual via respiration as well as spread via adsorption to atmospheric pollutants (gases and PMs). There is also a correlation between pm concentrations and the number of daily cases, and PMs, in particular, increase the frequency and severity of lung diseases.

Many precautions were taken as the virus spread around the world during the pandemic period. Among these measures are the cessation of industrial development procedures, the shutdown of logistics and human mobility while crossing borders, the restriction of all human activities, and, on occasion, the imposition of curfews by governments. Maintaining all of these general measures would minimize air pollutant pollution in cities, and thus, in addition to several environmental and human health issues caused by gas and PMs, the spread transmission of the Covid19 virus would be diminished.

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