



Virus-Laden Particles and Particulate Matter (Air Pollutants) with Viruses Attached: How Rumors that Air Pollutants Spread SARS-CoV-2 Are Born[†]

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Abstract: Premature and unsubstantiated claims that SARS-CoV-2 coagulates (creates clusters) with outdoor particulate matter (PM10) in the air and that SARS-CoV-2 can be transported by air pollutants became widely circulated in the media and have been cited by some studies as fact. Although the presence of the markers of SARS-CoV-2 (viral fragments of coronavirus) in environmental samples is an important finding, the media and researchers should be cautious regarding the claim that SARS-CoV-2 can create clusters with outdoor PM10 in the air and spread via particulate air pollution, as this statement is currently only a hypothesis that lacks direct or indirect supporting evidence.

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In recent studies [1, 2], Prof. Bontempi mentioned the problem of the lack of suitable terminology and confusion arising from the perception that the diffusion of airborne viruses can be promoted by outdoor sources (such as PM).

A study [3] of Setti et al. (May 2020) shows that the sampling and analysis of outdoor/airborne PM10 can be useful for detecting airborne RNA traces of SARS-CoV-2 and thus, identifying the presence of a potential viral hazard. This is an important finding and the method reported could be used to identify the early-warning signs and scale of an outbreak. It is important to note that as the authors pointed the limitation of this study is that the results did not demonstrate that SARS-CoV-2 was viable and infectious. However, one point in the text of the original paper may give the erroneous impression that SARS-CoV-2 is transported by air pollutants. An analysis of the data obtained by the authors and the literature cited by them in the text [3] shows that the conclusion that SARS-CoV-2 can create clusters with outdoor PM is unfounded and premature.

It is known that typical droplets generated by cough, sneeze or speech (e.g. $d < 20 \mu\text{m}$) can be airborne and remain so for a long time [4]: “..on initially $20 \mu\text{m}$ droplets was provided which can linger in still air for 20 min – 1 h”). Air flows may carry such aerosols for long periods, although the duration depends on the context. This is true even without assuming droplet drying, and particularly true when drying is taken into account (drying strongly influences the airborne duration). The evaporation process completes instantaneously for small respiratory droplets with an initial size of less than $20 \mu\text{m}$. These droplets evaporate rapidly to half of their initial size and become droplet nuclei [5]. Droplet

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nuclei are dry particles that may include viruses and other pathogens and tend to remain airborne; they thus could be distributed over a greater area than initial droplets.

As virus-laden droplet nuclei can be airborne, they could be collected in PM10 samples. However, it cannot be concluded from this fact that virus-laden particles create clusters with outdoor PM. Although such an “event” is possible, no direct evidence of such an event is provided by Setti et al. (2020) [3]. This is also true for all sources cited in their paper. Because to prove this it is necessary to conduct a microscopic examination of the collected samples which would show the clustering of virus-laden particles with outdoor PM. Microscopic examination of samples is a time-consuming and difficult task, and special measures are required when collecting samples (to exclude particle interaction post collection). Thus, from this point of view, virus-bearing aerosols from human atomization and virus-laden particles are not equivalent to particulate matter (air pollutants) with viruses attached.

As was rightly noted by professor Daniele Contini in a discussion on this matter (https://www.researchgate.net/post/Any_association_between_air_quality_and_virus_spread?isAnswerFieldFocused=true#view=5ea1bd46c620916f1b3acc9c): “Small droplets are released during respiration and speeches and these could evaporate (partly or totally leaving more or less dried residue) and they are sufficiently small to be suspended in atmosphere and transported/dispersed like the other particle. So the question is why they should be “carried” by other particles in air? They will also be transported by themselves like any other particle.” In addition, the results of the analysis of Bontempi [2,3] show that it is not possible to demonstrate that air pollution can accelerate virus diffusion, and moreover pandemic's diffusion patterns are typically caused by a multiplicity of environmental, economic and social factors.

Unfortunately, unfounded speculations and conclusions related to the spreading of SARS-CoV-2 by air pollutants are increasingly appearing in newspapers and research articles (see full review in [6]).

The original study of Setti et al. (2020) [3] and other available studies (see full review in [6]) do not provide sufficient basis for the conclusions that SARS-CoV-2 creates clusters with outdoor PM and that the pollution particles are similar to “micro-airplanes” with the (respiratory) droplets being the “passengers.” The analysis by Setti et al. (2020) [3] does not consider the possibility that virus-laden particles of different sizes (<10 μm) can be collected from the air and these particles are not equivalent to particulate matter (air pollutants) with viruses attached. Thus, the data presented by Setti et al. (2020) [3] and other researchers (see full review in [6]) do not provide direct or indirect evidence of the creation of clusters of SARS-CoV-2 with outdoor PM.

Thus, there is great ambiguity in the definitions of essential concepts related to the relationship between air pollution and coronavirus, including the concepts of “air pollution as a factor for health risk” and “SARS-CoV-2 spread by particulate air pollution”, and dispute over what constitute “virus-laden particles”, “droplet nuclei”, “virus-bearing aerosols produced from human atomization”, and “particulate matter (air pollutants) with viruses attached”. This ambiguity has resulted in deep misunderstandings between researchers and the spread of misinformation.

Although the presence of airborne SARS-CoV-2 in environmental samples is an important finding and its detection in such samples could serve as an early-warning sign and indicate the scale of an outbreak, readers, researchers, and the media should be skeptical of the claims that SARS-CoV-2 can create clusters with outdoor PM and that SARS-CoV-2 can spread by particulate air pollution as these are currently merely hypotheses that lack direct or indirect supporting evidence.

Supplementary Materials: A full version of the paper available at SSRN: <https://ssrn.com/abstract=3703004> or <http://dx.doi.org/10.2139/ssrn.3703004> [6]//additional material and data on seasonality of enhanced deposition of inhaled aerosols and pollutants due to the effect of air

supersaturation in the human airways as a factor of seasonality of respiratory infections (and probably of seasonality of COVID-19) see in [7-9].

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