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TREND EDITORIAL

Vitality of viruses, including SARS-CoV-2, in airborne particulate matter: the "micellar model" hypothesis

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Dear Editor,

More than two years after the official identification of the first cases in China (WHO 2020), and despite the development of several different vaccines, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and its related disease (Coronavirus Disease 2019, COVID-19) are still an epidemiological emergency of international concern.

Since the beginning of the pandemic, researchers around the world have wondered how this infective agent may have emerged, reasoning also on modalities and factors that affect its spreading, even if at the moment on these issues we have more questions than answers. As regards its diffusion, often occurring in a very unequal way within the same countries and even more among various geographical areas, Becchetti et al. reported the presence of two main "schools of thought" in the scientific community: the former is based on a purely epidemiological point of view, where the frequency of contacts among people and the viral load of each infected subject are emphasized, whereas the latter focuses on the existence of other factors, the most important of which is air quality (Becchetti et al. 2021). The papers published so far in the literature on air quality and the spreading of SARS-CoV-2 deal with two main points: (I) people living in areas with heavy air pollution have lung systems already somewhat more weakened and therefore are more prone to get sick with lung morbidities, like the COVID-19 syndrome; (II) air pollutants (especially particulate matter, PM) can act as a carrier for the novel coronavirus, probably facilitating its transport to distances greater than those covered by respiratory droplets. The role of carrier of atmospheric particulate towards bacteria (Romano et al. 2019) and various viral species (Chen et al. 2010; Ye et al. 2016; Chen et al. 2017; Peng et al. 2020) has already been demonstrated in dozens of studies, and in fact, many groups have tried to understand if this mechanism could be shared by SARS-CoV-2. Setti et al., for example, have showed not only that there is a robust correspondence between high PM concentrations and increased frequency of COVID-19 cases in Northern Italy during the first wave (Setti et al. 2020a) (which already anticipated a possible role of particulate matter as a carrier and infection booster) but also the presence of traces of SARS-CoV-2 viral RNA in PM_{10} samples collected in Bergamo (Setti et al. 2020b), one of the Italian cities most afflicted by the pandemic. However, this findings leave room for new questions and considerations: first of all, it is not clear if and how the particulate particles can directly determine the infection (in a mechanism closely linked to the viral load), and above all, it must be remembered that the evidences gathered so far indicates as viruses become progressively weaker when they are outside the human body, in particular in a context dominated by solar radiation which has windows (UV-A and UV-B, not completely absorbed by the ozone layer) endowed with some mutagenic activity and disinfectant properties.

Thus it might be interesting to point out a possible mechanism by which viruses in general, including SARS-CoV-2, could maintain their vitality even for some time in ambient air. The "micellar model" is based on the fact that atmospheric PMs (PM_{10} and $PM_{2.5}$ in the first phase, mainly the 2.5 component afterwards, less affected eventually by lockdowns and other social restrictions) (Mulder et al. 2021) or pollen grains (usually greater than 10 microns) (Ravindra et al. 2021), in addition to adsorbing viral particles on their surface, could partially or completely coat viruses, in a micellar-like structure. This could allow a more stable binding, facilitating their transport as well as protecting them from light, through the absorption (e.g., black carbon) or deviation of some wavelengths, and oxidative/chemical stress induced by oxygen and atmospheric pollutants (e.g., nitrogen oxides, and ozone), which could irreparably damage the external viral structures.

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This hypothesis needs to be validated by laboratory studies as well as in silico modeling and, if confirmed, could be important to provide new insights and clarifications on viral transmission modes and useful for policy makers in adopting new concentration limits and thresholds for particulate matter from an integral public health perspective, not only in a pandemic period.

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