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## Air quality and COVID-19: Much more than six feet. Evidence about SARS-CoV-2 airborne transmission in indoor environments and polluted areas

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In March 2020, while Italy was the first European country to experience the COVID-19 pandemic, the Italian Society of Environmental Medicine (SIMA) called for carefully considering the role of air pollution in boosting SARS-CoV-2 diffusion, as well as COVID-19 lethality in Lombardy and the neighborhood Northern Italian Regions (Setti et al., 2020a). After displaying the first evidence of SARS-CoV-2 RNA found on particulate matter of Bergamo before the first Italian lockdown (Setti et al., 2020b), the same researchers argued that the simple prescription of maintaining a social distancing of 6 feet (2 m) could not be enough to protect people from contagion, especially in enclosed spaces (Setti et al., 2020c). At that time, the use of facial masks in indoor or outdoor environments was not yet recommended by the World Health Organization, as well as by many Governments. As highlighted by Morawska and Cao (2020) and also by Paules et al. (2020), small particles with a higher viral load, could probably be transferred up to 10 m from the emission source in indoor environments, thus meaning more than 6 feet (2 m). Only in May 2021, due to the increasing evidence produced in medical literature (Domingo et al., 2020; Wu et al., 2020), the Centre for Diseases Control and Prevention (CDC, 2021) updated their official documents concerning the transmission of coronavirus SARS-CoV-2, recognizing that “once infectious droplets and particles are exhaled, they move outward from the source”, and that the transmission of SARS-CoV-2 might occur also at distances greater than six feet (2 m) from the infectious source. This despite being less likely than at closer distances, with the warning that “the progressive loss of viral viability and infectiousness over time is also influenced by environmental factors such as temperature, humidity, and ultraviolet radiation such as sunlight” (CDC, 2021).

An international research group (*Research Group on COVID-19 and Particulate Matter*, RESCOP) was fostered by SIMA. It was aimed at investigating possible links between COVID-19 and particulate matter, as well as the topic of indoor air quality in relation to COVID-19 diffusion. Starting from this initiative, *Environmental Research* set a thematic Commission on COVID-19 and outdoor/indoor air quality, which

promoted a Special Issue devoted to this specific topic.

About 150 papers have been submitted to this Special Issue, resulting in the publication (after peer review) of 60 of them. The vast majority of accepted papers addressed the topic of outdoor pollution and COVID-19, while 12 articles were about indoor air quality and SARS-CoV-2 transmission. Finally, 8 papers presented standardization of protocols or analytical methodologies, devices and procedures. These papers added relevant knowledge about coronavirus SARS-CoV-2 diffusion and COVID-19 severity in highly polluted areas, highlighting at the same time the need for maintaining particulate matter (PM) concentrations at lower levels, as well as optimal indoor air quality in community setting and public transportations, as crucial preventive measure in addition to inter-personal distance requirements and use of face masks to avoid premature deaths and SARS-CoV-2 spreading.

Barnett-Itzhaki et al. (2021) examined environmental and COVID-19 data from 36 OECD countries finding out that long-term exposure to air pollutants concentrations exceeding WHO guidelines (such as PM<sub>2.5</sub> and NO<sub>x</sub>) might exacerbate morbidity and mortality rates from COVID-19. Marqués et al. (2021) as well as Maleki et al. (2021) performed updated systematic reviews on the association between atmospheric PM pollution and SARS-CoV-2 incidence. Becchetti et al. (2021) analyzed the available literature concerning the link between air quality and a number of COVID-19 outcomes (assessing also the hypothesis of particulate matter acting as viral “carrier”). They showed the existence of a huge evidence produced worldwide concerning the role played by air pollution on health in general, and on COVID-19 outcomes in particular. Mele et al. (2021) assessed different NO<sub>2</sub> thresholds as a contributing factor to COVID-19 deaths in Paris, Lyon and Marseille, while Gujral et al. (2021) and Sangkham et al. (2021) performed similar assessments in California and in Bangkok Metropolitan area, respectively.

Indoor air quality in hospitals setting and nursing homes was tested by Zupin et al. (2021), Dargahi et al. (2021), as well as by Grimalt et al. (2021), who performed a systematic sampling and analyses of airborne

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SARS-CoV-2 RNA in different hospital areas including ICU rooms, finding out the presence of viral RNA in the rooms with COVID-19 patients and adjacent spaces.

On the other hand, Borro et al. (2021) and Aghalari et al. (2021) demonstrated that the coronavirus SARS-CoV-2 is mainly transmitted through exhalations from the airways of infected persons in hospital setting, while the proper use of Local Exhaust Ventilation systems (LEV) - simulated in the hospital rooms - is associated to a complete reduction of infected droplets spreading from the patient's mouth in the first 0.5 seconds following the cough event. In turn, Di Gilio et al. (2021) assessed - with positive results - specific user-friendly technologies to monitor CO<sub>2</sub> in 9 schools as indirect indicator of potential spreading of SARS-CoV-2 in case of one or more infected subjects, who were present at the same classroom. This methodology has been proposed for a proper management of windows/doors opening, but also as useful tool to discriminate those indoor environments, which definitely need to be equipped with decentralized double flow CMV (controlled mechanical ventilation devices), with pre-filtration of the incoming air, or continuous air extractors, and eventually air purification systems able to kill bacteria and viruses (with high performance HEPA filters or ULPA filters DFS for the removal of nanoparticles). Linillos-Pradillo et al. (2021) and Robotto et al. (2021) – under the initiatives promoted by the RESCOP in 2020 and 2021 – standardized specific methodologies for indoor/outdoor air sampling aimed at searching for SARS-CoV-2 RNA on particulate filters, which could be useful for the international scientific community to carry out further researchers on the topic of air quality and COVID-19, and add more evidence on those ones already produced.

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