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Evaluating COVID-19–Environment Fit

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Abstract. Spring came and went; the COVID-19 pandemic is still an inhabitant of the world, and its tendency to infect individuals is preserved in numbers; so, does the case fatality rate continues to increase. While a long list of facts provided by the clinical and medical sciences have remained unable to resolve the problem, recognizing environmental issues concerning COVID-19 resistance and adaptation might be a flash of lighting the nature of COVID-19 and its ideas of fitness. Here, we summarize the current state of the science of environment related to the causative pathogen of COVID-19, SARS-CoV-2, as follows. SARS-CoV-2 i. survives in water, ii. mainly spreads via the droplet route, and to a lesser extent, from touching contaminated surfaces, iii. transmission via droplets occurs within the interpersonal distance of two meters and beyond, iv. can more easily spread and cause more severe phenotypes of disease under higher-polluted, low-temperature, and low-humidity conditions, v. can spread under high-temperature conditions, and vi. transmission might be moderated by pollen-derived immune responses and lockdown-mediated air quality improvement. (www.actabiomedica.it)

Key words: Air, COVID-19, environment, fitness, immunity, pollution

Introduction

Areas inevitably undergo oscillations of environments, and these oscillations can act as a driver of viral outbreaks. For example, the respiratory syncytial virus (RSV) that accounts for more than 20% of acute lower respiratory tract infections displays a seasonal pattern, and this pattern varies in different regions. In the United States, analysis of data during one year demonstrates that south regions experience earlier and longer RSV seasons than other regions (1). During the COVID-19 pandemic, the United States has gained the first rank in terms of the total number of confirmed cases and deaths. As of May 22, 2020, COVID-19 has been the cause of pneumonia in more than five million cases, of which about one-third appeared in the United States. The COVID-19 pandemic started from urban areas of the United States and now has arrived exurban areas – the areas escaped from the initial wave of COVID-19. Overall, hotspot regions of COVID-19 mostly fall in the Southern regions of the United States. So, there is no reason to doubt about the force of the environment in keeping dynamic COVID-19 transmission. Here, we count environmental oscillations to exploit their COVID-19-related characteristics, hence to justify the necessity of environment-modifying solutions for the COVID-19 problem.

COVID-19 transmission is facilitated by polluted water

Water environments are a favorable source to many living microorganisms, and this source would greatly contribute to the preservation of transmission between humans. Poliovirus was the first virus detected in the water, leading to the development of a science named water virology. Further research has reported the viability of numerous viruses in water, in particular enteric viruses and avian influenza virus (2, 3). Using reverse transcriptase quantitative polymerase chain reaction (RT-qPCR), the study (4) found SARS-CoV-2 RNA in the wastewater collected in the catchment area. This finding that SARS-CoV-2 can survive in wastewater and, also, detection of the virus in stool (5) indicate that fecal pollution in water takes part in the rapid transmission of the virus.

COVID-19 transmission occurs via droplets within the interpersonal distance of two meters and beyond

The duration of the viability of SARS-CoV-2 varies by surface and medium ranging from a few hours (three to four hours) in aerosols and on copper to a few days (one to three days) on cardboard, stainless steel, and plastic (6). Therefore, SARS-CoV-2 can spread by inhalation and touching contaminated surfaces. However, the pathogen can more easily spread by the droplet route rather than by the surface route. Upon exhalation, a multiphase turbulent gas cloud will happen in addition to isolated mucosalivary droplets (7). The cloud includes both large droplets and small droplets – also known as aerosols – in the formation of clusters. These droplets become about a thousand times more stable than isolated droplets. When considering the momentum of the exhalation flow, the clustered droplets can maintain pathogen over seven to eight meters. Altogether, the high transmission of the virus seems to be mainly due to the airborne-transmission being maintained over and beyond the close interpersonal distance, and this maintenance is known to be strengthened with air pollution (8).

COVID-19 transmission is accelerated by the force of air pollution

The airways are directly exposed to air, and this holds how much are profound the effects of air pollution on the airway responses to respiratory viral infections, by means of which we can understand the parallelism between the effect of air pollution and the impact of human population density on transmission dynamics of the viral infections. More precisely, studies show that the generation of inflammatory responses is altered in the respiratory epithelium challenged by RSV and exposed to air pollution, and patients with co-existing conditions, e.g., asthma, suffer from the extremity of this alteration (9). In general, studies show that the lesser the air quality is, the numbers of new cases, total cases, and deaths from COVID-19 are larger (10). Analysis of data from 55 capitals in Italia (11) specified several important characters of COVID-19. First that the average number of COVID-19 cases grows by both the average human population density and cities-related factors. Its growth follows an arithmetic manner for the former factor while evolving in a geometric manner by the latter factor. When categorizing cities based on the number of days exceeding limits set for PM10 or ozone, a percent increase in population density corresponds with a more than three-fold increase in the number of COVID-19 cases (0.85 vs. 0.25) in higher polluted cities (with > 100 days exceeding limits set for PM10 or ozone) than in lower polluted cities (with ≤ 100 days exceeding limits set for PM10 or ozone). Second that compared to coastal cities and cities in south and center of country, there are conditions in hinterland cities and cities in north of country favorable to the transmission of viral infections, such as higher levels of air pollution, lower average temperature, lower average wind speed, lower number of rainy days, lower level of humidity %, and higher average days of fog. Consequently, it would be reasonable that these cities have embraced a higher number of COVID-19 cases. Altogether, the evidence indicates that cities-related factors, rather than the human population, will contribute to the force accelerating the COVID-19 transmission.

COVID-19 behaves more aggressively in regions with higher nitrogen dioxide levels

Nitrogen dioxide (NO_2) is an environmental challenge unfavorable to pulmonary anti-viral defense in many ways. It can reach alveolar macrophages and affect their power of producing interferons, which are the beginners of anti-viral immune mechanisms. By means of causing inactivation in alveolar macrophages (12), NO_2 confers susceptibility to and more severe phenotypes of respiratory infections raised from viruses, including influenza and RSV (13, 14). In the context of COVID-19, Each of Italy, Spain, France, and Germany have been among the top ten countries, totally accounted for about one-third of deaths related to COVID-19. Spatial analyses have remarked that the highest concentration of NO_2 exists in the five out of 66 administrative regions reported to be the worst regions in terms of case fatality (15).

COVID-19 is habituated to high temperatures

Air temperature and humidity can affect the behavior of viruses. Generally, studies show that the lower the air temperature and humidity, the longer the half-life of the viruses. For example, influenza has shown to efficiently spread in aerosols at the relative humidity (RH) of 20% to 65%, but not at high RH of 80% (16). Also, it was more able to transmit at 5 °C compared to 20 °C (16). The effects of weather vary for COVID-19. The study (17) included 678 cases with COVID-19 from January to March in Jakarta Indonesia and tested the effects of five weather variables (temperature minimum, temperature maximum, temperature average, humidity, and rainfall). The only variable reported to some extent to be related to the daily number of COVID-19 cases was temperature average. Also, analysis of data from death cases (n = 2299) in China (18) demonstrated that for every one-unit increase in temperature and absolute humidity, the rate of COVID-19 deaths decreases by 7.5% and 11.4% in lag 3, respectively, while their cumulative effects are not significant. Moreover, using data of 118 prefecture-level cities and four municipalities in China, the study (19) showed that there is no obvious linear correlation between temperature and the number of COVID-19 confirmed cases. When 3 °C was applied as the cutoff, the positive and negative effects of temperature rise appeared in the lower and upper cutoff temperature. However, the effect was only noticeable in the lower, not upper, cutoff temperature. The number of COVID-19 confirmed cases increased by 3.4% for each degree centigrade rise in the lower cutoff temperature (log 0 – 7). The corresponding decrease rate was less than 1% in the upper cutoff temperature (log 0 – 7). Another study of data from New York City within the period March 01 – April 12 revealed a positive association between temperature average and death from COVID-19 (10). Overall, it seems improbable that COVID-19 does act under confinement in high ambient temperatures, while the evidence shows an optimum temperature range for serving the human coronaviruses emerged earlier, such as SARS and MERS. Indeed, COVID-19 emerged in winter, lived throughout spring, and went straight into summer is another proof of that COVID-19 is habituated to high temperatures.

COVID-19 transmission might be moderated by pollen-derived immune responses

As they carry plant viruses, pollen can penetrate the host, induce immune responses, and bring allergies. Recently, the study (20) investigated the possible association between pollen, flu-like epidemics, and the use of hay fever medications in the Netherlands during a three-year period (2016 – 2019). Since hay fever medications are used to cure allergic or immune reactions and that pollen are a common cause of such reactions, the need to hay fever medications might reflect the number of immune reactions to pollen. Calculating weekly changes in flu-like consults over pollen counts clearly demonstrated that each surge in pollen counts corresponds to a drop in flu-like consults. In contrast, there was close parallelism between surges in flu-like consults and the use of hay fever medication. The findings support the view that pollen-derived immune responses are protective against flu-like diseases.

Lockdown: an intervention for COVID-19 that changes different components of air pollution

Studies show that lockdown could be successful in flatting the epidemic curves of COVID-19 in many countries. After Italy, Spain was the second European country affected by COVID-19 and has now placed the fourth rank in terms of the number of deaths. As of writing this, Spain seems to be at peace with COVID-19, which could not possibly exist without the activation of lockdowns. Before any lockdown occurred, a daily percent increase of cases diagnosed with COVID-19 was estimated to be about 40%, which was reduced to 12% by the first lockdown (March 16 – 30) and became negative by the second lockdown (since March 30) (21).

The study (22) evaluated the effect of lockdown on the meteorological parameters in Barcelona, Spain, in two sequential periods: February 16 – March 13 (before lockdown) and March 14 – 30 (during lockdown). Lockdown effectively reduced PM10, BC, NO_2, and SO_2, and that the effect was comparable for PM10 and NO_2 in both urban (PM10: 28%, BC: 45%, NO_2: 47%, and SO_2: 19%) and traffic stations (PM10: 31%, NO2: 51%, and SO_2: 2%). In contrast, the concentrations of O_3 increased by 29% and 58% in Urban and traffic stations.

Conclusion

Before this new one emerged, human coronaviruses seemed to us highly conserved in exhibiting similar characteristics such as low-stability in the environment, high sensitivity to oxidants, relatively faster inactivation kinetics in water compared to non-enveloped viruses, and remarkably reduced viability under high-temperature conditions (23–25°C) (23). Compared to the other human coronaviruses, this new one, SARS-CoV-2, has caused a surprising number of infected cases and deaths. Since late December, the research in biology and medicine has been largely devoted to the understanding of this viral infection, but the results of which failed to cure it. In this state, the integrated science of the environment can be applied to explain the extraordinarily transmission and mortality rate of COVID-19, and this application might be the only remedy to control the condition (24).

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