Review Article

Title: Atmospheric conditions affecting the transmission of Covid-19 virus

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Abstract

The physical environment plays an important role in the transmission of respiratory infections like Covid-19. To find relevant articles on environmental factors influencing respiratory infection outbreaks, we searched Pub med Central on the following topics: 1. Environmental pollution causing coronavirus fatality- 73 results, relevant 1 article, 2. Environmental factors affecting Covid-19, 149 results from which there were 6 relevant articles, 3. Impact of air pollution on Covid-19 fatality, 10 results, relevant 3 articles, 4. Environmental factors affecting respiratory viruses- 10646 results were obtained, 2 relevant articles. We searched Google scholar on environmental factors affecting Covid-19 transmission and found 7 relevant papers. We excluded the duplicates in each of the key words search. Date of search was on 20th April 2020. All articles included in results were scrutinized and relevance of articles was based on their content that discussed meteorological and physical environment factors in the spread and severity of Covid-19. We have discussed factors like air pollution, smoking, air temperature, humidity and air velocity as contributing factors. If meteorological factors are conducive to spread in a particular area, we need protective measures way before a respiratory infection outbreak occurs. Covid-19 is a lesson learnt the hard way, and we must enable people to practice hygienic practices with limited resources but high level of protection that it provides. Air pollution control can prevent priming of respiratory system which shall further protect from pulmonary infections.

Keywords: Covid-19, SARS-CoV, Environmental factors, Air pollution, Smoking, Air temperature

Introduction

Viral respiratory tract infections have similar manifestations as well as modes of transmission. Factors like air pollution may alter the respiratory tract and cause severe manifestations. There are other physical factors that enhance the virus transmission and should be considered when

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planning or strategizing control measures. With the emergence and re-emergence of respiratory viral diseases in different parts of our planet in the past decade, it becomes important to explore all plausible pathways other than mutation responsible for their transmission. Countries have notified Influenza, SARS-CoV, Ebola, Zika and NIPAH virus diseases in the past with wide spectrum of outcomes in terms of morbidity and fatality. The fight against them was not easy and with prompt public health efforts, followed by endemic regions, there have been established norms for the whole world in infection control methods. It is needless to emphasize that anything can happen as far as microbes are concerned. Similar to the aforementioned diseases, Covid-19 has become yet another spectacle in the world's arena that has swiped all of its human inhabitants with an economic, social, mental health crisis other than its implication on physical health and fatality. There are limited researches on the environmental factors associated with SARS-CoV-2 pandemic. Apart from the unique phylogenetics of novel coronavirus and host factors, here we are inclined to explore some physical environment factors that have lead to this disaster, and research on such factors must be carried out for future containment of respiratory diseases.

Research Methodology

1. We searched Pub med Central for articles based on the following key words:
    a. "Environmental pollution causing coronavirus fatality"- 73 results were obtained, with 1 relevant article downloaded,
    b. "Environmental factors affecting Covid-19"- 149 results were obtained from which 6 relevant articles were downloaded,
    c. "Impact of air pollution on Covid-19 fatality"- showed 10 results of which 3 articles were downloaded.
    d. "Environmental factors affecting respiratory viruses"- 10646 results were obtained, 4 relevant articles were downloaded
2. We searched Google scholar for key words- "environmental factors affecting Covid-19 transmission" and found 7 relevant papers that were downloaded.

We excluded all the duplicates in article search. Date of search was on 20th April 2020. All articles in the results were scrutinized and relevance of articles was judged based on their content that discussed meteorological and physical environment factors in the spread and severity of Covid-19.

A total of 21 articles were subjected to in-depth study before writing this review.

Air Pollution

Our physical environment includes air, land, water, plants and animals, buildings and infrastructure. "The immediate environment of man comprises of air on which depends all forms of life[1]". Nitrogen oxides in atmosphere cause air pollution. They give rise to particulate matter (PM) and acid rain. But they also cause decreased lung function and increased rate of respiratory infections[2]. There are existing postulates supporting air pollution as the reason for nCoV outbreak in affected countries. But, previously there have been no reliable studies documenting the correlation between air pollution and the SARS outbreak[3]. Air pollution is one of the most common causes of prolonged inflammation, eventually leading to an innate immune system hyper-activation[4].

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Let us begin with Italy being one of the first European countries to have handled COVID-19, with first cases detected in January 2020. In mid February, cases of community spread were detected in the region of Lombardy, and the outbreak soon involved all of Northern Italy, eventually appearing in other parts of the country[5]. The reasons that have been hypothesized for Italian outbreak are more number of elderly patients with high risk of respiratory infections and poor reporting and quarantine system in the initial stages of the outbreak. But, more number of young deaths needs inquisition into other factors such as air pollution. Air particles help to diffuse and disseminate the virus for many hours and days, helping in its survival and spread in higher polluted areas[5].

A study conducted by Sima[6] has shown that air pollution has played a key role in the propagation of SARS- CoV-2, although there is no evidence if it had rendered the community incapable to tackle the infection because of already poor health status. According to Conticini[4] et al, an exaggerated inflammatory status is found in airways exposed to air pollution, evidenced in an outdated paper that described, “alveolar macrophages (AM), exposed in vitro to PM10, significantly increased the levels of IL-1b, IL-6, IL-8 and TNF-a, thus underlining the prominent role of AM in cleaning particulates and activating immune response”. Such information was elaborated by another study about the effects of air pollution in Milan city (Lombardy, Italy) during winter (PM2.5) and summer (PM10) months on human bronchial cells showing an in vitro elevated production of both IL-6 and IL-8. Such priming of the immune system can occur even in the absence of causative microbial agents[5,7]. Daily concentrations of six air pollutants were measured, in 120 cities of China which included particles with diameters ≤ 2.5 μm (PM2.5), particles with diameters ≤ 10 μm (PM10), sulfur dioxide (SO2), carbon monoxide (CO), nitrogen dioxide (NO2), and ozone (O3). This data was correlated with average daily cases 12.94 from January 23rd to Feb 29th 2020. Short-term exposure to higher concentrations of PM2.5, PM10, CO, NO2 and O3 was found to be associated with an increased risk of COVID-19 infection. However, a higher concentration of SO2 was related to the decreased risk of COVID-19 infection in this study[8]. “The extent to which the COVID-19 virus induces respiratory stress in infected individuals may also be influenced by the extent to which an individual’s respiratory system is already compromised” and hence the role of air pollution as a co-factor in disease acquisition and severity can be emphasized[9,10].

Smoking

Smokers, both active and passive, are more predisposed to respiratory tract damage and hence acquire common colds (coronavirus and rhinovirus) more frequently than non smokers. Also their lungs are frequently affected by bacterial infections too. Studies have observed that smokers are associated with more hospital admissions after contracting influenza virus, from which we can form a corollary that smoking is associated with severe pulmonary infection manifestations[11,12].

According to Buono[5] et al, mortality rates of COVID-19 in Italy have been higher in men and elderly than in women. This could be because men are more frequent smokers with more frequent cardiovascular disorders than women. In South Korea, most infected by COVID-19 are young and non-smoking women who manifest as mild infections with low lethality. Therefore, it can be hypothesized that non-smokers exhibit mild infections[5].

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China has a high male smoking rate at around 50% in rural areas and is estimated to be about 44.8% spread across all country[13]. Most of the deaths identified from the epicenter of the Covid-19 outbreak were in people from older age groups (22.8% case fatality) for 70 years and above. Those with underlying co-morbidities died from COPD (6.3% case fatality), cancer (5.6% case fatality), hypertension (6% case fatality), diabetes (7.3% case fatality), or cardiovascular disease (10.5% case fatality). People who died with no co-morbidities were only 0.9%. The initial age distribution of Covid-19 cases was skewed towards older age groups with a median age of 45 years. The patients who died were maximum at the age of 70 years and above[14,15]. There is a need to correlate this data with prevalence of smoking in Chinese population so that it can be postulated as risk for contracting the disease as well as poor outcomes.

Recent studies have found that the modified S protein of SARS-CoV-2 exhibits higher affinity for ACE2 in human cells in comparison to the S protein of the previous SARS-CoV[15].Thus the virus has a prerogative in smokers who are found more likely to up regulate ACE2 expressed by type 2 pneumocytes on lung surface. Smokers show enhanced gene expression of ACE2 than non smokers, thereby increasing virus reproduction and transmission[16]. “The eventual engulfment of ACE2 further provides the virus access to the host cells system, thus providing a flourishing environment, not just to sustain and proliferate but also to mutate and modify host evasion mechanisms”. Smokers are the key population who may transmit and show severe forms of infection. They are also candidates for vaccination if it is developed in near future to fight nCoV[14].

Atmospheric Temperature

It is an established fact that respiratory pathogens of human beings such as human coronavirus is seasonal[17,18] and the 2003 SARS outbreak waned when the weather turned warmer, it is an analogy that meteorological conditions may have influenced the 2003 SARS outbreak.

Atmospheric temperature is an important factor influencing survival of microorganisms in the external environment. Several studies report that SARS-CoV is sensitive to temperature and relatively stable at low temperatures. As an example, the influenza virus persists in cold-dry weather with no UV radiation. Winters also reduce innate immunity due to deficiency of Vitamin D and hormone melatonin. People usually prefer closed spaces where they transmit influenza to each other. The lessons learnt from other respiratory pandemics may hold true for Covid-19 too. Some experimental evidence had shown that previous SARS-CoV agent remained stable at 4 deg C, at room temperature (20 deg C) and at 37 deg C for at least 2 h without remarkable change in the infectious ability of cells, but was converted to a non-infectious state after 90-, 60-, and 30-min exposure at 56 deg C, at 67 deg C, and at 75 deg C, respectively. Therefore, air temperature may not have only or adversely affected SARS-CoV transmission. And the same theory can be induced for nCoV pandemic[3,19,22].

Humidity and Air Current

Relative humidity is defined as the ratio of the water vapor content of the air to its total capacity at a given temperature. A high relative humidity and high temperature such that exists in tropical countries, is found to be a protective factor for respiratory viral infections[19].The survival of virus is supported in low humidity for days along with low temperature. Transmission of viruses via airborne routes may be affected by ambient humidity, which affects not only the virus’ stability

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but also respiratory droplet size, as water content evaporates. The droplet size influences how the particle will quickly settle to the ground or remain airborne long enough to be inhaled into the respiratory tract of a susceptible host. For example, the relative humidity is an important variable in droplet spread of influenza virus, high relative humidity favors removal of infectious particles both by increasing the mass of water-laden droplets causing it to settle and not be suspended in air and by hastening virus inactivation. In contrast, Adenovirus and Rhinovirus were more stable at high relative humidity[20]. Studies suggest that a high relative humidity level may shorten the suspending time of SARS-CoV in the air, as well as high wind velocity adversely affecting virus survival. Enveloped viruses like SARS-CoV thrive longer in dry air[3]. There may happen prolonged transmission of Covid-19 in lower humidity regions. However, there is paucity of research to support this hypothesis in the current scenario of this pandemic.

Evidence from various laboratory controlled experiments like animal models have elucidated potential mechanisms by which humidity and temperature affect human influenza virus transmission. As an example, in the early 1960s, Schulman and Kilbourne developed an influenza virus transmission model in mice. They observed a significant decrease in transmission efficiency with increasing relative humidity and during summer months[20,21].

In the outdoor environment, high wind velocity facilitates dilution and removal of the droplets and shortens their suspending time in the air, thus reducing the transmission potential. In contrast, indoor poorly ventilated rooms do not dilute the virus and make people residing in their closed spaces susceptible to infections for most respiratory infections. So cross-ventilation plays a role in clearing off the virus. Usually suspected carriers of the virus travelling or in contact with known Covid-19 cases must self isolate themselves instead of becoming a potential risk for health-care workers and other close contacts especially elderly and people with co-morbidities and the immunocompromised.

As a result, several investigators have propagated the use of humidifiers[22] in public spaces during the winter season. This may prove effective in influenza prevention, but for coronavirus, there is no robust evidence as yet.

Effects of Physical Factors on Survival of Virus Indoors

According to Yang et al[21], the concentration of airborne Influenza virus resulting from a cough would be reduced by 10% if the relative humidity increases from 35%, the mean indoor relative humidity in hot weather. The chance of infection diminishes to 50%, 10 min following the cough, and by 40% after 1 h in residential settings.

Casanova et al[23], carried out an experimental study to find out the effects of air temperature and relative humidity on survival of coronavirus on surfaces of hospital. For this purpose, two potential surrogates were evaluated: transmissible gastroenteritis virus (TGEV) and mouse hepatitis virus (MHV). They found that at 4 deg C, virus survived for 28 days. At all relative humidity levels, the infectious virus were inactivated more rapidly at 20 deg Celsius than 4 deg Celsius. The inactivation was slow at 20% relative humidity. We can imply the same characteristics to Covid-19 too but we need to support it with current evidence which is lacking still.

Conclusion

The physical environment plays an important role in the transmission of respiratory infections like Covid-19. We have discussed factors like air pollution, smoking, low air temperature, and low relative humidity and decreased air velocity as contributing factors. If meteorological factors are conducive to spread in our area, we need protective measures way before an outbreak can occur. We infer that during the colder and drier months or in places struck with polluted air, various preventive measures must be imbibed by the general population, both during this pandemic as well as during each season to prevent future spread of such diseases. Covid-19 is transmitted as an aerosol infection, and to nip in the bud, any other similar disease in future, we have to combat airborne transmission wearing of masks in highly polluted areas, practicing hand hygiene to prevent direct contraction of infections from contaminated surfaces, abstaining from active and passive smoking and maintaining distance from symptomatic individuals both at home and at work are some prevention measures. Covid-19 is a lesson learnt the hard way, and we must enable people to practice hygienic practices which utilize limited resources but provide high level of protection against this infection. Air pollution control can prevent priming of respiratory system by limiting exposure to toxic gases, which shall further protect from pulmonary infections.

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Conflict of Interest

None

References

1. K.Park. Park's Textbook of Preventive and Social Medicine. 25th ed. Jabalpur:M/s Banarsidas Bhanot. Feb 2019.
2. Howard Frumkin. Environmental Health From Global To Local. 3rd ed. San Francisco: Wiley & Sons, Inc. 2016.
3. Cai QC, Lu J, Xu QF, Guo Q, Xu DZ, Sun QW, et al. Influence of meteorological factors and air pollution on the outbreak of severe acute respiratory syndrome. Public Health. 2007;121(4):258–65.
4. Conticini E, Frediani B, Caro D. Can atmospheric pollution be considered a co-factor in extremely high level ofSARS-CoV-2 lethality in Northern Italy? Environmental Pollution, Available from: https://doi.org/10.1016/j.envpol.2020.114465
5. Buono M G D, Iannaccone G, Camilli M, Buono R D, Aspromonte N. The Italian Outbreak of COVID-19: Conditions, Contributors, and Concerns. Mayo Clinic Proc. 2020, Available from: https://doi.org/10.1016/j.mayocp.2020.04.003.
6. Setti L, Passarini F, De Gennaro G, Di Gilio A, Palmisani J, Buono P, Fornari G, Perrone M, Pizzalunga A, Barbieri P, Rizzo E, Miani A. Position Paper Relazione circa l'effetto dell'inquinamento da particolato atmosferico e la diffusione di virus nella popolazione. SIMA - Società Italiana di Medicina Ambientale; 2020. p. 1–5. Available from: http://www.simaonlus.it/wpsima/wp-content/uploads/2020/03/ COVID19_Position-

Paper_Relazione-circa-l'effetto- dell'inquinamento-da-particolato-atmosferico-e-la-diffusione-di- virus-nella-popolazione.pdf.

7. Ishii, H., Fujii, T., Hogg, J.C., et al., 2004. Contribution of IL-1 beta and TNF-alpha to the initiation of the peripheral lung response to atmospheric particulates (PM10). Am. J. Physiol. Lung Cell Mol. Physiol. 287 (1), L176eL183.
8. Qu G, Li X, Hu L, Jiang G. An Imperative Need for Research on the Role of Environmental Factors in Transmission of Novel Coronavirus (COVID-19). Environ Sci Technol. 2020; 0–2
9. Longhin, E., Holme, J.A., Gualtieri, M., Camatini, M., Øvrevik, J., 2018. Milan winter fine particulate matter (wPM2.5) induces IL-6 and IL-8 synthesis in human bronchial BEAS-2B cells, but specifically impairs IL-8 release. Toxicol. In Vitro 52, 365e373.
10. Yongjian Z, Jingu X, Fengming H, Liqing C. Association between short-term exposure to air pollution and COVID-19 infection: Evidence from China. Science of the Total Environment. Journal Pre-Proof. 2020, Available from: https://doi.org/10.1016/j.scitotenv.2020.138704
11. Eapen, M.S.; Sharma, P.; Moodley, Y.P.; Hansbro, P.M.; Sohal, S.S. Dysfunctional Immunity and Microbial Adhesion Molecules in Smoking-Induced Pneumonia. Am. J. Respir. Crit. Care Med. 2019, 199, 250–251. [CrossRef] [PubMed]
12. Han, L.; Ran, J.; Mak, Y.W.; Suen, L.K.; Lee, P.H.; Peiris, J.S.M.; Yang, L. Smoking and Influenza-associated Morbidity and Mortality: A Systematic Review and Meta-analysis. Epidemiology 2019, 30, 405–417. [CrossRef]
13. Zhi, K.; Wang, L.; Han, Y.; Vaughn, M.G.; Qian, Z.; Chen, Y.; Xie, L.; Huang, J. Trends in Cigarette Smoking Among Older Male Adults in China: An Urban-Rural Comparison. J. Appl. Gerontol. 2019, 38, 884–901. [CrossRef] [PubMed]
14. Brake SJ, Barnsley K, Lu W, McAlinden KD, Eapen MS, Sohal SS. Smoking Upregulates Angiotensin-Converting Enzyme-2 Receptor: A Potential Adhesion Site for Novel Coronavirus SARS-CoV-2 (Covid-19). J Clin Med. 2020;9(3):841
15. Sun, K.; Chen, J.; Viboud, C. Early epidemiological analysis of the coronavirus disease 2019 outbreak based on crowdsourced data: A population-level observational study. Lancet Digit. Health 2020. [Cross Ref]
16. Zhao, Y.; Zhao, Z.; Wang, Y.; Zhou, Y.; Ma, Y.; Zuo, W. Single-cell RNA expression profiling of ACE2, the putative receptor of Wuhan 2019-nCov. bioRxiv 2020. bioRxiv:2020.01.26.919985
17. Dowell SF, Ho MS. Seasonality of infectious diseases and severe acute respiratory syndrome—what we don't know can hurt us. Lancet Infect Dis 2004;4:704–8.[Cross Ref]
18. Hendley JO, Fishburne HB, Gwaltney JM. Coronavirus infections in working adults. Eight-year study with 229E and OC43. Am Rev Respir Dis 1972; 105:805–11. [Cross Ref]
19. Priyadarsini SL, Suresh M. Factors influencing the epidemiological characteristics of pandemic COVID 19 : A TISM approach Factors in fluencing the epidemiological characteristics of pandemic COVID 19 : Int J Healthc Manag [Internet]. 2020;0(0):1–10. Available from: https://doi.org/10.1080/20479700.2020.1755804
20. Pica N, Bouvier N M. Environmental factors affecting the transmission of respiratory viruses. Current Opinion in Virology 2012, 2:90–95
21. Yang W, Marr LC. Dynamics of Airborne Influenza A Viruses Indoors and Dependence on Humidity. Plos One.2011; 6(6).

 doi:10.20944/preprints202005.0467.v1

22. Sloan C, Ph D, Moore ML, Ph D, Hartert T. Review Articles Impact of Pollution , Climate , and Sociodemographic Factors on Spatiotemporal Dynamics of Seasonal Respiratory Viruses. 2010; 4(1).
23. Casanova LM, Jeon S, Rutala WA, Weber DJ, Sobsey MD, Carolina N, et al. Effects of Air Temperature and Relative Humidity on Coronavirus Survival on Surfaces . 2010; 76(9):2712–7.