Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Chronic exposure to air pollution implications on COVID-19 severity

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ABSTRACT

Populations in areas with higher levels of air pollution both indoors and outdoors show increased mortality rates when infected with coronavirus disease 2019 (COVID-19). The association between air quality and COVID-19 is commonly attributed to the risk of transmission. Although controlled transmission is crucial, further investigation into air quality traits that contribute to the lethality of COVID-19 in infected persons enables risk stratification and optimization of the allocation of resources. There is a need for a valid basis for the proactive identification of indicators of COVID-19 severity in air quality that allow for the implementation of systematic environmental improvements aimed at preventing COVID-19 mortality. In this paper, chronic exposure to fine particulate matter (PM) is identified as a source of disrupted activation of the hypothalamic–pituitary–adrenal (HPA) axis; it is therefore, a contributable variable to COVID-19 mortality.

Background

Combating the mortality rate of COVID-19, in addition to hygiene measures, must include improving the host environment like air quality to prevent comorbidity in the immune response of infected hosts. Despite increased interest in air quality associations with COVID-19 transmission, many studies pay minimal attention to the impact of air composition on COVID-19 severity. Although populations in highly polluted areas, both indoor and outdoor, are associated with COVID-19 pathology and increased likeliness of mortality [1–4].

Typical immune response requires activation of the inflammatory pathways of the immune system [5]. However, if the immune system is disrupted, an abnormal response may elevate the impacts from viral infections [5]. The immune system has mechanisms in preparation for various pathogens. A crucial mechanism in the innate immune response regards cytokine production and its interplay with HPA system activation [6]. In this paper, the imposition of such severity from COVID-19 in highly air polluted environments may be attributable to the recorded effects particulate matter (PM) in air composition has on the HPA axis, disrupting immune response. This paper discusses the relationship between populations chronically exposed to fine PM and the intensity of COVID-19 infection, and its link to the HPA axis interplay with the immune system.

Hypothesis

Populations in environments with elevated fine particulate matter (PM) levels, both indoors and outdoors, are hypothesized to be at increased risk to COVID-19 pathogenesis. Firstly, we discuss the link between HPA axis disruption and COVID-19 symptom severity. Secondly, we discuss the chronic exposure to the fine PM role in disruption of the HPA axis.

Support for Hypothesis

Communication and feedback are codependent between the HPA axis and the immune system. The association between chronic immune activation and the pathogenesis of COVID-19 is recognized in patients with chronic inflammatory conditions [5,6]. The HPA axis modulates immune responses, and cytokines within the immune system such as IL-1, IL-6, IL-10 and TNFα activate the HPA axis [7–9]. This interplay is aimed to protect the body from immune system dysregulation and minimize tissue damage from associative systemic inflammation [7,8,10,11]. Chronic activation of the HPA axis affects the release of glucocorticoids and contributes to immune dysfunction as immune response is signified by glucocorticoid release [7,12–15].

Due to the critical interplay of the HPA axis and the glucocorticoid response in maintaining a balance between the beneficial and harmful effects of proinflammatory cytokines and influencing immune responses, there are dynamics between the cytokine-HPA axis that are fundamental to the maintenance of the immune system. A disrupted activation of the HPA axis may result in immunosuppression or hyper activation of a particular immune response. The differences in these outcomes are dependent on individual differences among a variety of factors [6–8]. If infected with COVID-19, populations with a disrupted HPA system activation and cytokines are at an increased risk for

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mortality. In people infected with COVID-19 higher than standard levels of certain plasma cytokines were recorded. Tan's report found that elevations in serum cortisol, taken 48 h within hospital admission, were predictors of poor outcomes in COVID-19 patients. A 42% increase in mortality is shown in patients in cortisol levels measured above 744 nmol/L after confounding variables were adjusted [16]. This suggests deregulation of serum cortisol, typically associated with disrupted HPA system activation which may be predictive of morbidity and mortality from COVID-19. Building upon the inference that chronic activation of the HPA axis disrupts immune response it is necessary to consider air pollution impacts on HPA baseline function. Chronic exposure to fine particulate matter (aerodynamic diameter $\leq$ 2.5 μm; PM 2.5) is well observed in both disrupted HPA baseline function and acutely increased glucocorticoid secretion [17–20]. In addition, fine PM exposure has been observed with overexpressed cytokines such as: TNFα, IL-1 and IL-6, crucial cytokines in the interaction of the HPA axis and immune response [5,20,21].

Chronic exposure to fine PM has a recorded correlation to an increase in the likeliness of mortality from COVID-19. Wu et al. from Harvard, observed populations in locations with higher levels of fine PM are 8% more likely to die from COVID-19 than people who live in an area with lower levels of fine PM [3]. In addition, the number of confirmed cases of COVID-19 and associated hospital admissions or fatalities are correlated in locations with higher levels of fine PM and PM10 [22,23]. Hospital admissions imply COVID symptoms are severe enough to require professional observation and formalized treatment. Therefore, chronic exposure to fine PM may be contributable variable that disrupts HPA system activation typically associated with the altered regulation of circulating glucocorticoids resulting in inefficient or delayed immune response to COVID-19 infection. Clearly, the implications from fine PM exposure are observed in conduction with COVID-19 mortality.

Conclusion and Discussion

In conclusion, chronic fine PM exposure may contribute to the variation in morbidity and mortality observed in COVID-19 infections due to disrupted immune response characterized by HPA system disruption in addition to already recognized impediments on lung function. This reasoning aims to elucidate the environmental factors attributing to the disproportionate severity of COVID-19 infections experienced in populations with low socio-economic backgrounds.

If fine PM plays a significant role in COVID-19 pathogenesis, institutions can employ mitigation strategies to prevent mortality. This study emphasizes the importance of minimizing sources of fine PM in both indoors and outdoors, especially indoors as humans spend an overwhelming amount of their life indoors. Efforts in reducing the magnitude of indoor source emissions include controlling occupant density, improved ventilation, revaluation of building life cycles; these variables overlap with the precautions to reduce COVID-19 transmission while car exhaustion is well recognized source of fine PM outdoors. Environmental precautions should be reinforced and further evaluated in geographical locations and built environments to minimize the variables that result in higher levels of fine PM. Experimental, and epidemiological studies are urgently needed to assess the role of air pollution in specific populations.

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Declaration of Competing Interest

The author declare that there are no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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