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Original article

Effect of environmental pollution PM2.5, carbon monoxide, and ozone on the incidence and mortality due to SARS-CoV-2 infection in London, United Kingdom

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abstract

Objectives: COVID-19 pandemic raised several queries on the relationship between the environment pollution and occurrence of new cases and deaths. This study aims to explore the effect of environmental pollution, particulate matter (PM 2.5 μm), carbon monoxide (CO) and Ozone (O3) on daily cases and daily deaths due to Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) infection in a largest metropolitan city London, United Kingdom.

Methods: For this study, we selected London, one of the highly populated capitals, and markedly affected due to COVID-19 pandemic. The data on the SARS-CoV-2 daily new cases and deaths were recorded from UK-gov Web “Coronavirus COVID-19 in the UK, 2020”. The daily environmental pollutants PM 2.5 μm, CO and O3 were recorded from the metrological web “(London Air Pollution, Air Quality Index- AQI, 2020)”. The daily cases, deaths, PM 2.5 μm, CO and O3 were documented from the date of the occurrence of the first case of SARS-CoV-2 in London, February 24 to November 2, 2020.

Results: The SARS-CoV-2 cases and deaths were positively related with environmental pollutants, PM2.5, O3 and CO levels. Additionally, with 1 μm increase in PM2.5, the number of cases and deaths significantly increased by 1.1% and 2.3% respectively. A 1 unit increase in CO level significantly increased the number of cases and deaths by 21.3% and 21.8% respectively. A similar trend was observed in O3, with 1-unit increase, the number of cases and deaths were significantly increased respectively by 0.8% and 4.4%.

Conclusions: Environmental pollutants, PM2.5, CO and O3 have a positive association with an increased number of SARS-CoV-2 daily cases and daily deaths in London, UK. Environmental pollution management authorities must implement necessary policies and assist in planning to minimize the environmental pollution and COVID-19 pandemic.

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1. Introduction

Environmental pollution develops a hazardous situation, and causes significant wide-ranging damage to the regional environment, human health and living organisms (Meo et al., 2020a). Worldwide, people are migrating from rural areas to the metropolitan cities (Mathias, 2020). The metropolitan cities are facing the challenging issues of overcrowded population, large number of motor vehicles, and constructions of unplanned industries. These factors increase the environmental pollution both at regional and international levels. The environmental pollutants are mainly consisting of “dust, fumes, smoke, carbon dioxide, carbon monoxide, nitrogen oxides”, particulate matter, hydrocarbons and other organic compounds (US Environmental Protection Agency, EPA, 2020; Pandey and Singh, 2019). Worldwide, many metropolitan cities are affected by environmental pollution.

London, a capital city of United Kingdom, is one of the highly populated, and congested metropolitan cities, is facing major health care challenges of environmental pollution and a rapidly increasing number of SARS-CoV-2 cases. On Dec 4, 2020, the total number of SARS-CoV-2 cases in United Kingdom, are 1659260,
deaths 59,699 compared to worldwide total number of cases of SARS-CoV-2 are 64,350,473 (2.57%) and deaths 1,494,668 (3.99%) (World Health Organization, WHO 2020). In London, where the total number of SARS-CoV-2 cases are 161,626 compared to total number of cases in the entire United Kingdom are 165260 (9.74 %) (London Data, 2020). One of the reasons of rising cases of SARS-CoV-2 in London may be the environmental pollution which makes the city more susceptible to infectious diseases such as SARS-CoV-2 infections (London Data, 2020). It has already been reported that environmental pollution and weather conditions have an impact on the pattern of health and disease (Meo et al., 2020).

The incidence of SARS-CoV-2 may be linked to living in "urbanization, habitat destruction, live animal trade, intensive livestock farming and global travel" (Barouki et al., 2020). The impact of environmental pollution requires further studies. The present study aims to investigate the effect of environmental pollutants "particulate matter PM2.5, carbon monoxide (CO), and Ozone (O₃) on the daily incidence and deaths due to SARS-CoV-2 infection in London, UK".

2. Materials and Methods

The present study was steered in the “Department of Physiology, College of Medicine, King Saud University, Riyadh, Saudi Arabia”. In this study we selected London, UK, one of the highly populated metropolitan capitals, affected by the environmental pollution and SARS-CoV-2 infection. Data were extracted from publicly accessible databases. The information on SARS-CoV-2 daily cases and deaths were collected from the UK-gov Web "Coronavirus COVID-19 in the UK, 2020)". The daily information on meteorological conditions, environmental pollution, daily pollutants, particulate matter PM2.5, CO and O₃ were obtained the metrological web-(London Air Pollution, Air Quality Index- AQI, 2020). The daily cases, deaths, pollutants, particulate matter PM2.5, CO and O₃ were recorded from the date of appearance of first case of "SARS-CoV-2" in the London, from February 24, 2020 to November 02, 2020.

Ethical Statement: For this study the data on the daily new cases and deaths due to COVID-2019 pandemic, particulate matter PM2.5, CO and O₃ related information were obtained from the UK-gov Web "Coronavirus COVID-19 in the UK, 2020)", and weather web “AQI” from the publicly available data bases, hence ethical approval was not required.

2.1. Statistical analysis

The data was analyzed using “R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria”. One-sample Kolmogorov-Smirnov test was used to evaluate the assumptions of Normal and Poisson distributions. Median (25th–75th quartiles) are reported for non-normally distributed quantitative variables (number of cases, deaths, PM2.5, CO and O₃). Spearman Rho Correlation was applied to assess the relationship between various pollutant parameters with the number of cases and deaths at 1% level of significance. After fulfilling the assumptions, the Poisson regression analysis was performed to predict the number of cases and deaths from pollutant parameters. Goodness of Fit tests and Model tests for all regression analysis were significant. An α = 0.05 was considered as statistically significant.

3. Results

The median (25th–75th quartile) number of new daily cases reported in London between 24th February to 2nd November 2020 were 168 (57.5–567) and deaths 4 (1–15), whereas the median PM2.5, CO and O₃ levels were 24 (18–38), 2 (1–4) and 21 (15–28) respectively (Fig. 1). The number of cases significantly increased with the increase in PM2.5 level (ρ = 0.341, p < 0.001), a similar trend was observed where O₃ level was significantly positively related with the number of cases (ρ = 0.222, p < 0.001). Moreover, a positive association was noticed between the number of cases and CO level, but it did not achieve a level of significance (ρ = 0.120, p = 0.057).

In addition, the number of deaths also significantly increased with the increase in levels of PM2.5 (ρ = 0.395, p < 0.001), CO (ρ = 0.125, p = 0.047) and O₃ (ρ = 0.450, p < 0.001). Results are presented in Figs. 2, 3 and 4.

Fig. 1. Median PM2.5, CO, O₃ levels and number of cases and deaths during the period February 24 to November 2, 2020.
Results presented in Tables 1 and 2 demonstrates that, 1 μm increase in PM2.5 the number of cases and deaths significantly increased by 1.1% and 2.3% respectively. Whereas 1 unit increase in CO level the number of cases and deaths again significantly increased by 21.3% and 21.8% respectively. A similar trend was observed with O3 pollutants, results showed that with an increase of 1 unit in O3 the cases and deaths were significantly increased by 0.8% and 4.4%.

4. Discussion

Environmental pollution is a growing global public health concern. It changes the environment, weather conditions, and increases the risk for respiratory (Meo et al. 2020b), nervous system (Meo et al. 2019c), cardiovascular (Meo and Suraya, 2015d), and endocrine (Meo et al. 2020c). Environmental pollutants have various sources of emission, biological, physical, chemical, and
spreading behaviors (Jeong et al., 2019). The present study findings are showing increasing trends of SARS-CoV-2 cases and deaths with environmental pollutants PM2.5, CO and O3 levels in London, United Kingdom.

Literature acknowledged that the environmental pollution increases the incidence and mortality of respiratory infections (Kan et al. 2005). (Kan et al. 2005) reported that the coronavirus outbreak increased by 6% with a relative risk of mortality for each 10 μg per cubic meter increase in the mean of total respirable particulate matter PM-10, which also comprises of PM2.5 and larger particles. Similarly, (Croft et al., 2018), and (Croft et al., 2020) found that short-term or long-term upsurges in particulate matter PM2.5 from traffic and various combustion sources are a potential risk for high incidence of influenza, and hospitalizations with culture-negative pneumonia and influenza.

Earlier studies have also established a link between high concentrations of ambient fine particles, PM2.5 and respiratory infections (Cannon et al., 2018; Gandini et al., 2018). Similarly, the present study results revealed a positive correlation between the environmental pollutants PM2.5, CO and O3 and number of cases and deaths of SARS-CoV-2.

(Razzaq et al. 2020) established a relationship between air pollution mainly ground ozone O3 and COVID-19 cases in the states of the US. The authors found a positive relationship with high environmental pollution and increase susceptibility of COVID-19 cases. Similarly, (Loili et al., 2020) investigated the role of air pollution on transmission of SARS-CoV-2 infections. The authors concluded that air pollution (PM2.5) shows a positive correlation at lesser degree. COVID-19 pandemic transmission prefers dry and cool weather conditions as well as polluted environment.

Bianconi et al. (2020) reported the risk of particulate matter exposure, “PM2.5 and PM10 with the COVID-19 cases and deaths” across the Italian regions. They also concluded that PM pollution plays a role in the outbreak of COVID-19 cases in Italian regions.

Zhu et al. (2020) found a significant positive association between air pollutants including PM2.5, PM10, CO, O3 with COVID-19 infection. In another study, (Frontera et al. 2020) reported that regions with high air pollutants, “PM2.5 and NO2” have high incidence and mortality due to SARS-CoV-2 infection. Similarly, the present study findings show an increasing trend of COVID-19 cases and deaths with environmental pollution in London, UK.

More recently, (Meo et al. 2020a; Meo et al. 2020b) reported that PM2.5, CO, and O3 concentrations generated due to wildfire was associated with increases in the COVID-19 cases and deaths in various regions of the California, USA. The literature show that environmental pollution and weather conditions possibly affect the transmissibility of SARS-CoV-2 infection (Meo et al. 2020g; Meo et al. 2020h).

Liu and Li (2020) showed that ground-level ozone was positively correlated with county-level mortality rates. High ground-level ozone and nitrogen dioxide concentrations contribute to a greater COVID-19 mortality rate. Similarly, Comunian et al. (2020) reported that short-term and long-term exposure to high concentrations of pollutants, particulate matter were linked to an increased in COVID-19 infection. Pozzer et al. (2020) suggested that environmental pollution is a major cofactor for increasing risk of deaths due to COVID-19 pandemic.

The SARS-CoV-2 can be easily transported through the air and pollutants. Air is a highly suitable transmission method in which microorganisms including “bacteria, fungi, viruses, parasites, and spores may move around the environment of various regions (Zhou et al. 2020; Setti et al., 2020). The environmental particulate matters play a role as a carrier of numerous microorganisms including viruses. The particulate matters increase the effectiveness of the viruses spread and provide suitable environment for its persistence (Setti et al., 2020). Moreover, PM2.5 along with microorganisms can be easily inhaled deep into the lungs, mainly those pollutants which are smaller than PM2.5 microns, fine and ultrafine particulate matters. This may facilitate the virus to enter, grow within the respiratory system and cause infections (Setti et al., 2020).

The literature is supported by some evidences that exposure to environmental pollutants, PM has been causally linked to organ dysfunctions mostly involving the respiratory system (Schraufnagel et al., 2019) and also severe course of SARS-CoV-2 infection (Leikau et al., 2020).

The environmental pollution PM 2.5, CO and O3 may act as a carrier of the infection, impair the immunity, making the people more susceptible to pathogens, and as a worsening pathogenic factor for the disease*** (Zhou et al. 2020). In’t Veen et al. (2020) reported a correlation between severity of SARS-CoV-2 infection and air pollution. The mechanisms by which air pollution might facilitate SARS-CoV-2 infection include a possible link between upregulation of the angiotensin converting enzyme receptor by air pollution and the host being prone to more severe COVID-19.

The present study findings have evidences that particulate matter PM2.5, CO and O3 are the possible sources of carrier or transport vector for SARS-CoV-2 virus. Moreover, CO is a highly toxic gas which can damage the lungs. This mechanism supports the hypothesis that the environmental pollutants particulate matters PM2.5, CO, O3 resulted in an increase in the SARS-CoV-2 cases and deaths.

### 4.1. Study strengths and limitations

This is the first study added in literature that has investigated the effect of environmental pollution particulate matter PM2.5, CO and O3 on the incidence and mortality trends of SARS-CoV-2 infection in a largest metropolitan city, London. We selected the main pollutants, PM2.5, CO and O3, as these pollutants are sharp to decline deep into the lungs. The limitation of this study is that, we were unable to consider other pollutants such as PM 2.10, carbon dioxide, and weather conditions which may also affect the dynamics of the COVID-19 epidemic. Further studies are suggested to develop a comprehensive understanding of the various environmental factors involved in COVID-19 pandemic.

### 5. Conclusions

The present study results identified a relationship between environmental pollutants, particulate matter PM2.5, carbon

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**Table 1**

| Pollutant Parameters | β   | S.E  | Exp (β) | p-value          |
|----------------------|-----|------|---------|-----------------|
| PM 2.5              | 0.011 | 0.0002 | 1.011 | p < 0.001*      |
| CO                  | 0.193 | 0.0015 | 1.213 | p < 0.001*      |
| O3                  | 0.008 | 0.003  | 1.008 | p < 0.001*      |

**Table 2**

| Pollutant Parameters | β   | S.E  | Exp (β) | p-value          |
|----------------------|-----|------|---------|-----------------|
| PM 2.5              | 0.023 | 0.0005 | 1.023 | p < 0.001*      |
| CO                  | 0.197 | 0.0067 | 1.218 | p < 0.001*      |
| O3                  | 0.043 | 0.0012 | 1.044 | p < 0.001*      |

**statistically significant at 5% level of significance; S.E = Standard Error; β = Coefficient Estimates; Exp (β) = Exponentiated Values.**
Declaration of Competing Interest

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

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