Air pollutants and SARS-CoV-2 in 33 European countries

Lembo Rosalba [1], Landoni Giovanni [1,2], Cianfanelli Lorenzo [1], Frontera Antonio [1]

[1] *IRCCS San Raffaele Scientific Institute, via Olgettina 60, Milan, Italy*
[2] *Vita-Salute San Raffaele University, Milan, Italy*

Introduction

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic is characterized in its severe forms by severe acute respiratory distress syndrome.

Why some countries were more severely affected than others is one of the pandemic's most puzzling traits. Several factors have been called into question, such as climate [1], population density [2], genetic of the population [3] and SARS-CoV-2 virus spike protein mutation [4].

Air pollution has been correlated with SARSCoV-2 outbreaks [5-7]; and the persistence and the high contagion rate of some areas might be justified by specific orographic and climate factors which may create a hood of air pollutants [8]. Angiotensin-converting enzyme 2 (ACE-2) receptor overexpression at the alveolar level in individuals chronically exposed to air pollution is one probable reason [9]. In fact, ACE-2 receptors are known to be SARS-CoV-2 entry sites in the cells [10], and higher expression might make patients more susceptible. Furthermore, nitrogen dioxide, whose concentration in polluted areas is high, is a potential booster for mortality [9]. This study aimed to correlate SARS-CoV-2 outbreaks with air pollution in Europe.

Methods And Materials

The number of SARS-CoV-2 positive and COVID-19 deaths per country were exported from the WHO website for the Situation Report number 118 [11].

Data on six air pollutants were extracted from the EUROSTAT website [12]. Another extraction was performed for greenhouse gas emissions from EUROSTAT based on European Environment Agency information [13]. The rate of elderly (>65 years old) people in each European country except Liechtenstein was obtained from EUROSTAT and United Nations [14]. Twenty countries listed in WHO as European regions were excluded from the analysis for missing data.

To investigate the potential relationship between air pollutants, greenhouse gas emissions, SARS-CoV-2 positive cases and COVID-19 deaths in all countries, Pearson correlation analysis was applied for the overall population, normalizing for the elderly population.

Normalization for age was calculated as the total number of positive cases and deaths divided by the elderly population multiplied by 1000. To control the type I error rate due to multiple comparisons, Bonferroni correction was used and the adjusted level of significance was $p < 0.05$ after this correction.

Results

A total of 1,480,130 SARS-CoV-2 positive cases were collected from 33 European countries from 11th February to 17th May 2020.

The highest number of positive cases was collected from the United Kingdom, Spain and Italy. Luxemburg, Iceland, and Spain were the three nations with the highest number of SARS-CoV-2 positive cases when cases had been normalized for the population over 65 years old. Mortality was extremely variable among countries. The highest number of deaths was reached by the United Kingdom, followed by Italy and France. After normalization for the elderly population, the countries with the highest number of deaths were Belgium followed by Spain and the United Kingdom.

Air pollutants recorded across European countries in 2017 were correlated with both the SARS-CoV-2 cumulative positive number of cases and the cumulative number of COVID-19 deaths.

A significant association was found to be present as high levels of ammonia, nitrogen oxides, non-methane volatile compounds, particulate matter <10 micrometers (PM_{10}), and particulate matter <2.5 micrometers ($PM_{2.5}$) were linked to a high number of positive cases. Similarly, high environmental levels of the same pollutants, except for PM_{10}, were associated with a high number of deaths. $PM_{2.5}$ ($r = 0.68$ with p-value = 0.0001; $r = 0.73$ with p-value <0.0001) and nitrogen oxides ($r = 0.85$ with p-value <0.0001; $r = 0.70$ with p-value =0.0001) were the pollutants with the strongest correlation for infections and deaths. Figure 1 shows the linear correlation between $PM_{2.5}$ levels and normalized cumulative deaths for people over 65 years old per 1000, describing how countries with the highest $PM_{2.5}$ concentration are the ones with the greatest number of victims.

Conclusions

The main finding of this study is that high levels of particulates and greenhouse gases are associated with SARS-CoV-2 infections and that $PM_{2.5}$ and nitrogen oxides are the pollutants with the strongest correlation for both positive cases and deaths. Environmental factors may play an important role in increasing susceptibility to severe outcomes of COVID-19. Air pollution in urban areas is a true cocktail of contaminants represented by gases, semi-volatile liquids, and particles. During the 2003 outbreak of SARS in China studies found urban areas with severe air pollution had higher mortality rates than low pollution areas, although these results were not adjusted for important confounders, such as age, sex and comorbidities [15].

Exposure to air pollutants is known to be associated with a higher incidence of respiratory and cardiovascular diseases and a higher number of deaths [16]. Moreover, areas with elevated concentrations of pollutants are the ones with the highest population density where disease transmission is favored [17]. It is therefore likely that a combination of the aforementioned factors may favor the establishment of overt SARS-CoV-2 infection and may promote different illness severity, eventually leading to a higher rate of mortality in most polluted areas.

Furthermore, it has been hypothesized that chronic exposure to $PM_{2.5}$ may cause overexpression of ACE-2 receptors [9]. Although the number of studies on this issue is still scarce, most results indicate that chronic exposure to air pollutants may lead to more severe and lethal forms of this disease and complicate recovery [18].

After normalizing mortality data for the elderly population, air pollutants were associated with high infection and deaths.

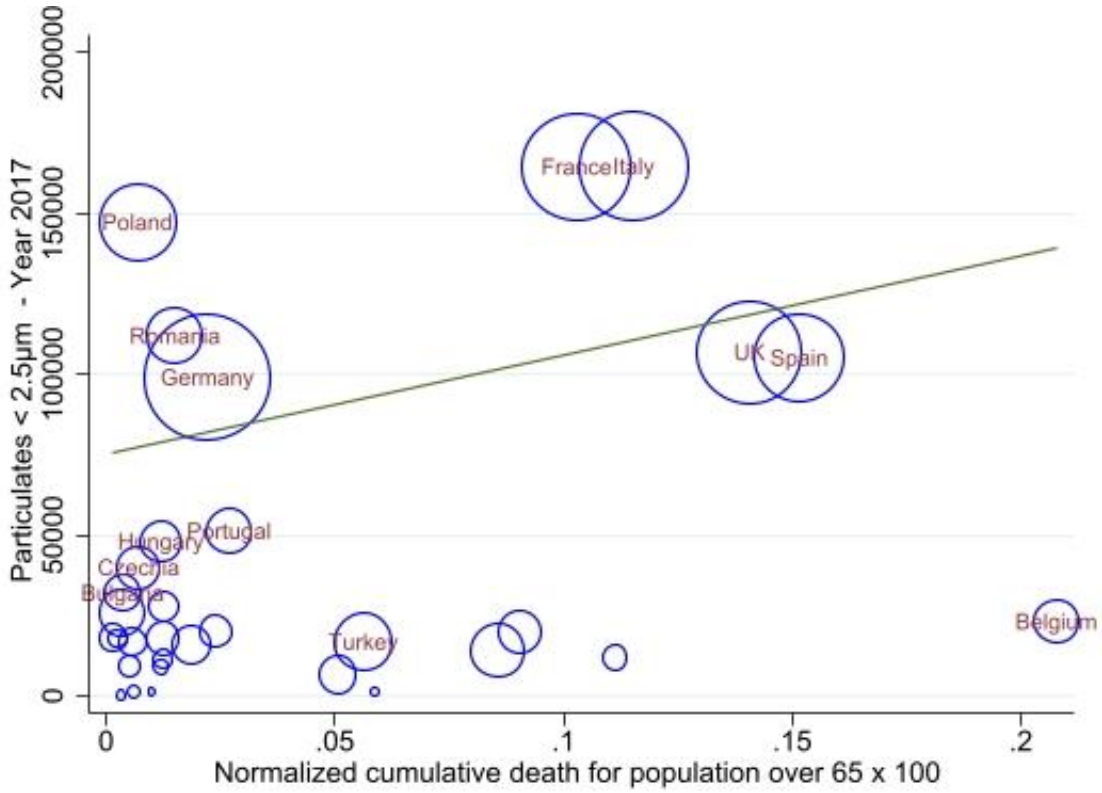

Figure 1. Correlation between particulates<2.5µm emission and normalized cumulative COVID-19 deaths for population over 65 years per 1000 – Circles sized for population

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