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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Letter to editor regarding Ogen Y 2020 paper: "Assessing nitrogen dioxide (NO2) levels as a contributing factor to coronavirus (COVID-19) fatality"

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A recent publication of Ogen (Ogen, 2020) that examined the relationship between long-term exposure to nitrogen dioxide (NO_2) and coronavirus fatality raises the very important question on the impact of air pollution on health. Unfortunately, it does not provide sufficient basis for its conclusion that NO_2 is "*one of the most important contributors to fatality caused by the COVID-19 virus in these regions and across the whole world*" as claimed in the abstract. The analysis has not considered data on any other factor possibly determining COVID-19 fatality, besides NO_2 levels.

Statisticians always emphasize: "*correlation does not imply causation*". And as a geographer investigating air pollution aspects, my additional concerns are for Figs. 3 and 4 in the Ogen manuscript (Ogen, 2020). The correlation in Fig. 3 might be due to a superposition of other causes which this study does not reflect on how large are the 66 regions used for the analyses, and what are their environmental factors? Just studying the association between number of COVID-19 deaths to regional pollution levels is meaningless without considering such key confounding factors as the size and population density, socio-economic conditions, age and land use (for example using a regression model). Furthermore, the observed correlation in Fig. 3 (Ogen, 2020), could easily be produced by the fact that number of deaths (due to any disease) tends to be, by nature, greater in a larger population, which has a larger number of NOx sources (and higher NO_2 concentration). The scatter plot in Fig. 3 is dominated by such "outliers". The latter seem to "improve" the relashionship between two variables. We also need to consider a sensitivity analyses that will clarify the impact of large cities on the studied association.

Questioning Ogen's conclusions means asking anew. Can we perform such analyses using only two months of exposure to NO_2 and define it as a long-term as was done by the author? The answer is ***No***. As evident from publically available data sources from the European Environmental Agency, NO_2 is showing a decreasing trend over the recent decade in western Europe, including Italy, Germany, and Spain (https://www.eea.europa.eu/data-and-maps/daviz/emission-trends-for-the-main-6#tab-chart_1; https://www.leopoldina.org/uploads/tx_leopublication/2019_Leo_Stellungnahme_Saubere_Luft_en_web_05.pdf). However, air pollution is still one of the major environmental problems with the wide range of health effects (https://www.epa.gov/isa/integrated-science-assessment-isa-nitrogen-dioxide-health-criteria). To study its impact we need to look at much longer period. Does the long-term exposure to air pollution increases the vulnerability of population to COVID-19? Such hypothesis has been formulated, by Conticini et al. (2020) as a co-factor in extremely high level of SARS-CoV-2 lethality in Northern Italy. In the USA, Xiao Wu et al. (2020) found that long-term average exposure (2000–2016) to fine particulate matter ($PM_{2.5}$) increases the risk of COVID-19 deaths.

We need also to consider the multiple pollutants influences in a separate study (Crouse et al., 2015) and carefully investigate the spatial distribution (and variability) of NO_2 and/or particulate matter concentrations above all studied locations as the pattern for each will be different for different urban settings under different meteorological and geographic conditions (Chudnovsky et al., 2013). Specifically, Ogen (2020) calculated the average concentrations for entire administrative regions without adjustment to population density and spatial variability in NO_2. These values might be not representative to the population exposure.

My final comment relates to the whole validity of using satellite retrieval without any ground based NO_2 monitoring sites validation. Specifically, the retrieval provides NO_2 levels as Dobson Units (DU), meaning that it measures the total number of molecules in a vertical column, which is not the same as the concentration at ground level. It is difficult to draw any specific health-outcome conclusions from this data, because the pollution is dispersed at different heights in the atmosphere. For example, satellite versus ground-based calibration was done in many studies for different air pollutants and further used in exposure related studies (e.g. Lee and Koutrakis, 2014; van Donkelaar et al., 2019). Even without such calibration, comparison to ground monitoring sites is necessary.

The current number of around 205 thousand deaths of COVID-19 (as to April 26, 2020), shows high contiguity of the virus, and a need exists to establish a global worldwide policy to have fast response in such events. There are countries with much higher NO_2 concentrations but low fatality rate and Taiwan is the best example (based on OMI NO_2 open satellite data engine available at https://giovanni.gsfc.nasa.gov/giovanni/doc/UsersManualworkingdocument.docx.html). The country strategic planning is the cardinal reason for the successful prevention of the virus spread: with fewer than 400 confirmed COVID-19 cases and six confirmed deaths. More research and scientific discussions are urgently needed to answer critical questions associated with air pollution impact and environmental confounders.

Declaration of competing interest

Yaron Ogen is a student of my former PhD adviser. During my PhD he started his master thesis. On my return to the Department as a faculty member, Yaron was at his last stages of PhD. I know Yaron as a wonderful student and personality.

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