Response to the commentary by Alexandra A. Chudnovsky on '*Assessing nitrogen dioxide (NO₂) levels as a contributing factor to coronavirus (COVID-19) fatality*'

Dear Editor

I wish to thank Dr. Alexandra Chudnovsky for her valuable time and effort to write the comments on the paper. I always appreciate any review given by my colleagues.

My recent study "*Assessing nitrogen dioxide (NO₂) levels as a contributing factor to coronavirus (COVID-19) fatality*" (Ogen, 2020) was published as a short communication in *Science of the Total Environment*. The main purpose of short communication article is to provide "A brief communication of urgent matter or the reporting of preliminary findings to be given expedited publication". The nature of such works is usually accompanied by innovation, creative thinking, and out-of-the-box ideas. Moreover, they are incomplete and intended to equip scholars with an idea that needs further exploration. With that saying, I fully agree with Dr. Chudnovsky that my study "does not provide sufficient basis" for any conclusion related to the influence of NO₂ on fatality but I did suggest, that this should be investigated. In addition, I would like to add that my work by itself does not prove any causality between NO₂ and fatality caused by COVID-19, only to show that high fatality was observed in regions with high concentration of NO₂ and it does not eliminate the potential impact of other risk factors.

Dr. Chudnovsky asked "How large are the 66 regions used for the analysis, and what are the environmental factors related to them?". The study was conducted on the first administrative regions for each country for two reasons: first, performing any study on a country level and comparing data between different countries would not supply any geographical/environmental insight about the disease. Second, the data on fatalities was published online by the ministries of health for each administrative region. An additional assumption was that people who live and work in one region and are exposed to air pollution would likely be treated in a hospital in their home district. The regions differ in size, and for a preliminary study it was enough in order to understand the spatial distribution of the pollution and receive important insight which might assist other researchers in future studies.

Regarding Dr. Chudnovsky's remark about the influence of other environmental factors such as population that should be taken into consideration, I do agree that more comprehensive studies should be conducted. Therefore, as Dr. Chudnovsky requested, I have added an additional graph using the same database, showing NO₂ concentration and fatality adjusted to the population in each region (Deaths per 100,000) which might supply an additional insight (Fig. 1). Again, this graph does not claim any causality between the two parameters, but only to show a trend that should be investigated and weighed in future studies.

Dr. Chudnovsky also suggests removing any "outliers" from the data. However, I disagree with that suggestion. As the world is still facing the COVID-19 pandemic, these outliers are the greatest story tellers. They may provide the most important knowledge needed to solve the global problem. These hotspots draw the connecting line and might be the key to humanity's wider understanding of the disease.

Another issue that Dr. Chudnovsky pointed out was the period that was used in the study and this is indeed arguable. However, what is the right period that should be used? Including a long period in the analysis may raise other question related to the temporal/seasonal changes which might create more complications. In order to neglect the seasonal interference, I decided to focus on the two winter months prior to the outbreak in Europe.

Dr. Chudnovsky cited the Leopoldina report (https://www.leopoldina.org/uploads/tx_leopublication/2019_Leo_Stellungnahme_Saubere_Luft_en_web_05.pdf) in order to provide proof that NO₂ levels in western Europe is showing a decreasing trend over the recent decade. However, this does not mean that the ambient air is clean enough for not causing any health problems, moreover, in the same report it was also written that the limit values of NO₂ are still frequently exceeded. "*The pollutant load in air has decreased significantly in recent decades. This includes nitrogen dioxide and particulate matter. Nonetheless, the limit values are still sometimes exceeded – frequently for nitrogen dioxide and rarely for particulate matter.*"
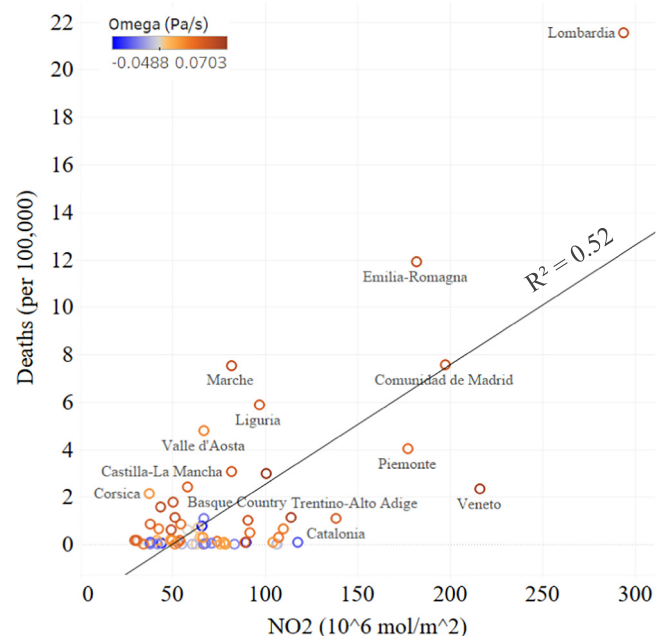

Fig. 1. NO₂ vs. the number of death cases (per 100,000). The color scale presents the vertical airflow at 850 mb.

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Dr. Chudnovsky provided two recent references that studied the effect of air pollution on COVID-19 fatality. First is the study of Conticini et al., 2020 that investigated several pollutants including NO_2 in north Italy and concluded that "*the high level of pollution in Northern Italy should be considered an additional co-factor of the high level of lethality recorded in that area*". The second study was conducted by Wu et al., 2020 who focused on $PM_{2.5}$ and concluded that "*long-term average exposure (2000–2016) to fine particulate matter ($PM_{2.5}$) increases the risk of COVID-19 deaths*". Each of these studies was conducted within a certain boundary (either the north Italy region or focusing only on one pollutant, i.e. $PM_{2.5}$) and were conducted during the pandemic in order to try to solve the global crisis. As a researcher, I cannot deny the work of others because they suggested a solution which is different from mine, on the contrary. These studies, including mine, support one another. Neither is perfect nor provide a definitive answer to the problem, but each adds another piece of knowledge to the scientific puzzle. Nevertheless, a new study found that "*the levels of some markers of poor air quality, nitrogen oxides and ozone, were associated with COVID-19 mortality in different English regions, after adjusting for population density*" (Travaglio et al., 2020).

Regarding the ground validation of the NO_2 data, I totally agree with Dr. Chudnovsky. Indeed, the most accurate NO_2 value can be extracted using validation data, however, and as I already mentioned, this is only a preliminary study that highlights one of the environmental factors that should be considered and thus, more comprehensive studies should be conducted on this subject.

In addition, Dr. Chudnovsky brings Taiwan as an example for an area that suffers from high NO_2 levels but few death cases. However, in my study I only focused on 4 west European countries. This is an important issue in order to eliminate any cultural differences and, more importantly, results do not determine that in highly polluted areas there is high fatality, but exactly the opposite. It showed that the highest number of cases was observed in highly polluted areas.

To summarize, my study '*Assessing nitrogen dioxide (NO_2) levels as a contributing factor to coronavirus (COVID-19) fatality*' was written and published during the pandemic. Researchers all over the world are working hard to investigate and search for any new methods and theories on how to solve the on-going global crisis. The global community, including Dr. Chudnovsky should welcome any new novel and creative thinking and nurture each other with knowledge and new ideas.

References

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Yaron Ogen
The Department of Remote Sensing and Cartography, Institute of Geosciences and Geography, Von-Seckendorff-Platz 4, Room H4 2.23, Martin-Luther University Halle-Wittenberg, Halle (Saale) 06120, Germany
E-mail address: yaron.ogen@geo.uni-halle.de