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A basic epidemiological study on the association between air quality and COVID-19 lethality in India and United States

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ABSTRACT

Introduction: Coronavirus disease 2019 (COVID-19) is a global pandemic level, respiratory system targeted virus infection. The impacts of smoking habits, genetics, and chronic medical conditions such as lung cancers on COVID patients has been assessed extensively so far. However the role of the ambient air quality as a vital factor of life, in COVID 19 mortality risk is not yet properly studies. The association and correlations between ambient air quality and mortality risk has been assessed in this study at a preliminary scale using basic statistical analysis in India and United States of America (USA); two countries with highest COVID prevalence in the world.

Materials and methods: Pearson's Chi-squared test for independence was employed to assess the associations and CramerV statistics was used to evaluate the strength of associations between mortality and air quality. Pearson's product-moment correlation and Spearman's rank correlation were employed to assess the correlation between ambient air quality and deaths.

Results: In the study, the risk of mortality appeared to be significantly dependent on the level of ambient air quality in both countries. However the strength of association was significantly low in both cases. The correlation between ambient air quality and mortalities in both countries also appeared to be significantly low. However the correlation in USA appeared to be higher than in India.

Conclusion: Based on above results it can be concluded that the risk of mortality is dependent on ambient air quality, but air quality might not be the only dominant definitive factor for mortality. However further research might be required at pathological level to theorize the above relationship.

Introduction

Coronavirus disease 2019 (COVID-19) is a virus infection that started as a local outbreak in Hubei province of the China in 2019 and rapidly upgraded to global pandemic by 2020. The etiology for the infection is discovered as 'Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) which is a kin of Severe Acute Respiratory Syndrome (SARS) and Middle East

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Respiratory Syndrome (MERS).

As for the structure of corona virus, they are positive sense single-stranded Ribo Nucleic A (RNA) virus with a genome size of approximately 30 kb, enveloped by a lipid bilayer. The genomes consist of 2 major regions as ORF1a and ORF1b followed by genes that encode 16 non-structural proteins (nsp1–16) and 4 structural proteins, Spike (S), Envelope (E), Membrane (M), and Nucleocapsid (N). The viral surface proteins; S, E and M, are embedded in the lipid bilayer surrounding the genome and N proteins are associated with viral RNA in nucleocapsid. While M and E protein play a significant role in viral assembly, S-protein is responsible for host cell receptor (Human ACE2) binding and fusion [1]. Non-structural proteins assembles in to multi-protein Replicase-Transcriptase Complexs (RTC) such as RNA-dependent RNA polymerase (RdRp) that play a significant role in viral replication cycle and proofreading mechanisms [2].

As the name of virus itself express, the infection mechanism as well as pathological consequences are highly associated with respiratory system. Due to that reason the associations of unhealthy lifestyle practices such as smoking, existing lung complications such as lung cancer, as well as genetic effects to COVID severity and mortality had been studied by now [3-5].

In the other hand the ambient air quality has also proven to be directly associated with general pulmonary medical conditions such as acute exacerbation of chronic obstructive pulmonary disease based on studies done in various regions such as China, and Philippines, etc. Hence just as in any usual respiratory disease, in COVID 19 also the quality of ambient air must have a role to play [6, 7].

Even though the effect of COVID 19 on ambient air quality as a result of its impact on socioeconomic operations globally had been assessed deeply, the impact of air quality on COVID 19 severity risk has not yet been systematically studied. Prior to extensive studies, establishment of basic relationships and patterns of associations (simply to check whether there is any association or not) is important.

In this study we have assessed basic associations and correlations between ambient air quality and risk of death in COVID 19 infections with the intention of establishing those basic relationships. However, ‘air quality’ is quite a broad variable since it is not an individual element or substance, but a representation of complex mixture of various gases and volatile aerosols. Hence the parameter used to represent air quality should at least consist of major air pollutants. The best solution for this is using an index (a single figure that can represent all) such as Air Quality Index (AQI) which is already including measurements of ground level Ozone (O_3), Particle Pollution ($PM_{2.5}$, PM_{10}), Carbon monoxide (CO), Sulfur dioxide (SO_2) and Nitrogen dioxide (NO_2).

Further, the natural exposure always occur in form of mixtures, but not individual substances in air. Also synergistic effect of mixtures can be quite different than individual components in context of the mode of action of different pollutant and their associated pulmonary pathology (Ozone induced oxidative stress, inflammation and airway remodeling [8] but $PM_{2.5}$ induce lung cancer [9]). The adverse responses in the body are also integrated and systemic rather than local. In this case, the pathological data of how individual substance affect COVID associated pulmonary pathology and complications, is not yet studied in detailed mechanistic levels. Most of all, individual parameters such O_3, $PM_{2.5}$, PM_{10}, CO, SO_2 or NO_2 are not equally, systematically recorded and readily available for all the locations of COVID incidences used here (one place might have O_3 data but lack $PM_{2.5}$ data. Using $PM_{2.5}$ data for other locations and not using for that particular location might rise standardization issues). This could make standardization issues of results. Never the less, it would require a complex multivariate regression analysis approach to assess effects that can be affected by above incomplete variables. But using, AQI which is already calculated using individual components which represent major air pollutants and compiled into a single surrogate variable instead of registered concentrations of individual pollutants simplifies the whole process as well as increase the credibility of results.

Hence in the process we have used Air Quality Index (AQI) values for a particular location and classification as a scale for air quality or air pollution [10].

Outcomes of this study can provide the solid baseline required for further deep dives in terms impact of air quality and its sub components on COVID 19 lung pathology of physiology. Further, this would allow recognizing better ambient air conditions that can improve the treatment environment of COVID patients in order to reduce the risks of lethality. Especially when medical facilities run out of resources and space under massive outbreak conditions these slight changes of factors might make a huge difference between probability of life and death.

Materials and methods

Data collection

The average Air Quality Index (AQI) values for 33 Indian states and 50 states of United States of America (USA) were obtained using AQI–Realtime Pollution Monitoring platform, USA.com-U.S. Air Quality Index State Rank data platform and IQAir Air quality API platform data bases. Total number of COVID-19 cases and death tolls data for each of above states in India and USA were obtained from 'Google COVID News data platform based on Johns Hopkins University, Our World in Data' data base.

Association between air quality and COVID-19 lethality

The recovered numbers of patients were calculated using number of deaths and total number of cases for each state in both countries. The total recovered numbers and deaths were categorized into five air quality categories as Good, Moderate, Unhealthy for sensitive groups, Unhealthy and Very unhealthy based on AQI values of states that cases were reported. Data was organized into a contingency tables and Pearson's Chi-squared test for independence was carried out to assess whether the death or survivability of a patient is dependent of air quality group. Further CramerV statistics were calculated to quantify the strength of association. Process was repeated for India and USA both countries [11, 12].

Correlation between air quality and COVID-19 lethality

Deaths in each states was converted into Percentage (as a percentage of total cases in each state). For preliminary visualization for signs of correlations, Percentages of deaths were graphed against AQI values on scatter plots.

Next, Shapiro-Wilk normality test was carried out for above death percentages and Air Quality Index (AQI) values of states prior to correlation assessment. Based on the normality or non-normality of each variable, either Pearson's product-moment correlation or Spearman's rank correlation was applied to calculate correlation between Death percentages and AQI values. Based on that, Pearson's product-moment correlation was applied for India and Spearman's rank correlation was applied to USA data [13-15].

Results and discussion

Association between air quality and COVID-19 lethality

When deaths and survived numbers were categorized into air quality groups in India as in the Table 1 below, when air quality was worse or unhealthy the percentage of death appeared to higher (1.36, 1.31 and 1.3%) in Unhealthy for sensitive groups, Unhealthy and Very unhealthy groups consecutively) compared to better or satisfactory air quality conditions (1% in Moderate group). It is approximately 30% higher death probability compared to moderate regions.

(Note: Air Quality Index scale as defined by the US-EPA 2016 standard; Good (0 – 50), Moderate (51 -100), Unhealthy for sensitive groups (101-150), Unhealthy (151-200), Very unhealthy (201-300) and Hazardous (300+))

According to Pearson's Chi-squared test for independence results in India, the survivability or mortality of COVID 19 patients appeared to be significantly dependent on the air quality index group ($p<2.2e-16$) at 95% significance level. Hence it appeared that Air quality was associated with the probability of surviving. As for the strength of this association, even though the existence of association was clearly noticeable, the strength appeared to be significantly weaker based on CramerV statistics ($0.0162<0.5$).

Regarding USA also the survivability or mortality of COVID 19 patients appeared to be significantly dependent on the air quality index group ($p< 2.2e-16$) at 95% significance level and hence the probability of surviving seemed associated with air quality. However, in here also the strength of association appeared to extremely weaker

Table 1. The total recovered numbers and deaths in 33 states of India categorized based on Air Quality Index (AQI) values

	Survived		Died	
	Numbers	%	Numbers	%
Moderate	18817042	98.99	190418	1
Unhealthy for sensitive groups	15906829	98.63	220820	1.36
Unhealthy	3347852	98.68	44526	1.31
Very unhealthy	2743630	98.69	36170	1.3

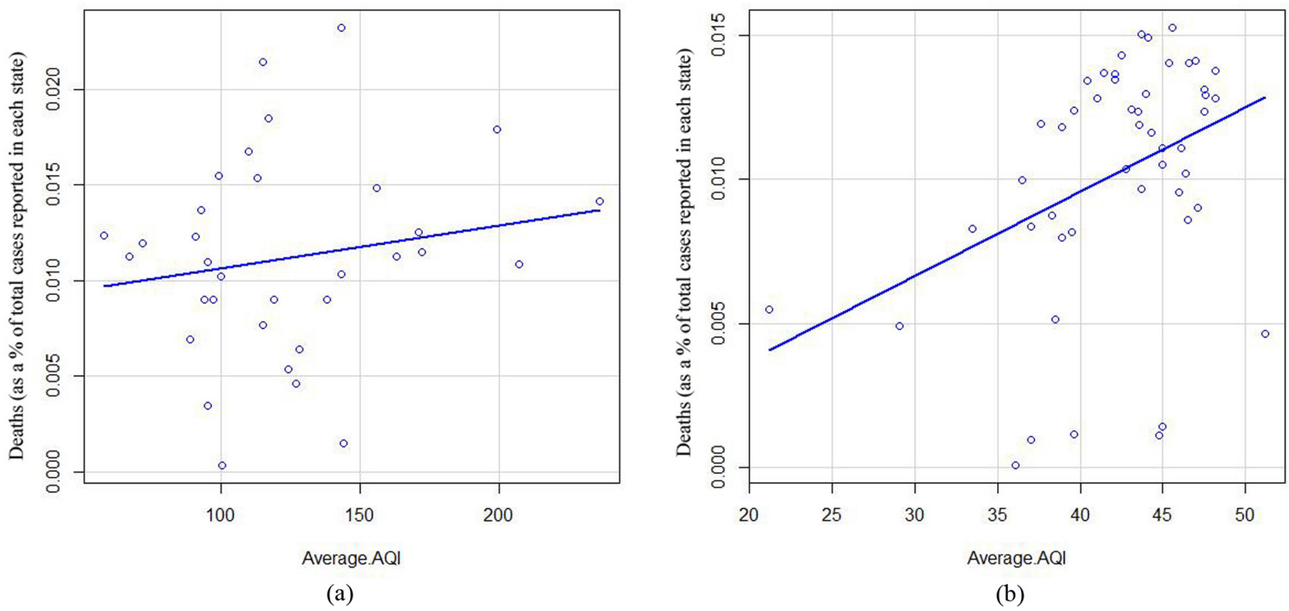

Fig. 1. Scatter plots for percentages of deaths vs Average AQI values, (a) 33 states of India, (b) 50 states of USA

even than in India based on CramerV value (0.006974<0.5). (CramerV=0.5 is intermediate strength while >0.5 is a strong association).

Correlation between air quality and COVID-19 lethality

When percentages of deaths were graphed against AQI, and least square line for data points was estimated, a slight positive slope was observed in Indian data set (Fig. 1a) and a significantly steep positive slope was observed in USA data points (Fig. 1b). Further in USA data set, this slope was significantly higher compared to Indian situation. Based on those visual observations, a positive correlation was apparent between Average AQI values and death percentages.

According to Shapiro-Wilk normality test results for India, data in Average AQI values (p=(0.0576)>0.05) and Percentages of deaths (p-value (0.9571)>0.05) both variables appeared to be normally distributed. Hence when Pearson's product-moment correlation was applied, the true correlation coefficient (p (0.3373)>0.05) was not appeared to be significantly different from 0 at 95% significance level. Further the correlation was significantly low (cor=0.1724372) since it was less than 0.5. These low correlation value appeared to be justifying the low strength of CramerV association (0.0162) observed before, between AQI value categories and survival categories in India.

According to Shapiro-Wilk normality test results for USA, data in Average AQI values (p (0.0002394)<0.05) and Percentages of deaths (p (0.00005968)<0.05) both variables appeared to be not normally distributed. Hence when Spearman rank correlation was applied, the true correlation coefficient (p (0.007956)<0.05) was appeared to be significantly different from 0 at 95% significance level. Further the correlation was not significantly high either (ρ= 0.3711994) since it was less than 0.5. This low correlation values were further evident for low strength of association (0.006974) observed before, between

AQI value categories and survival categories in USA again. However the value difference of correlations between India (cor=0.1724372) and USA (ρ=0.3711994) appeared to be clearly justifying the steepness difference of slopes in scatterplots quantitatively.

These extremely low 'Pearson's Chi-squared test for independence' results for India ($p < 2.2e-16$) and USA ($p < 2.2e-16$), both suggests that the survivability or mortality of COVID 19 patients appear to be significantly dependent on the air quality index or air pollution. But it does not quantify the strength of correlation between survivability and air quality. By this stage it simply signifies the existence of relationship regardless of the strength of correlation. Hence, based on this, 'air quality' cannot be completely ignored as an effector on death as a COVID outcome and with this assurance, the correlations can be assessed. Hence it appears that air quality play an unassessed, unquantified role in COVID lethality at this moment.

In quantifying this correlation in both countries, Pearson's product-moment correlation (r) of India being 0.1724372, with extremely low CramerV association of 0.0162 and Spearman rank correlation (ρ) of USA being 0.3711994 with extremely low CramerV value of 0.006974 again emphasize the low correlation between AQI and COVID deaths in both regions. This strongly implies that even though AQI and COVID deaths are dependent, AQI may not be a strong driving factor of COVID induced deaths. Hence the major factors could be chronic pulmonary diseases (that can be indirect effects of chronic exposure to air pollution), habits such as smoking, diet and obesity or even genetics, immune compromisation as well as lack of medical care or access to medical facilities during pandemic etc. in this two regions. If this was simply the situation of one region, it could be considered as a local effect. However the data of both regions showing similar patterns it justifies the outcomes as a global trend beyond geography.

However, as this is a passive preliminary study that simply focus on simple relationship and dependency of air quality and COVID lethality, the study strongly recommend further active studies employed with animal models inhalation toxic exposure experiments followed by active viral challenge studies to evaluate pathological aspects, mechanisms and adverse outcome pathways of these relationships.

Conclusion

Based on above observations, the mortality risk of COVID 19 patients appeared to be significantly dependent on the air quality surrounding them. But the strength of association between mortality and air quality was not significantly high, perhaps due to stronger influence of multiple other driving factors associated with risk of mortality such as genetics (3p21.31 gene cluster – [16]), medical history with severe complications (lung cancer), smoking behaviors etc [3, 4]. However to understand the full extent of these associations, a novel research approach with more detailed experimental designs are required at pathological level. In the process, assessing the involvement of more air quality parameters such as Particulate Matter (PM) and other gaseous components (Carbon dioxide, Carbon monoxide and oxides of nitrogen) and designing experiments to understand underlying mechanisms at individually or synergistically might provide solid information to theorize the association between air quality and COVID 19 mortality risk.

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Competing interests

Author assures that there is no competing interest in publishing this work in the journal.

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Ethical considerations

Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc) have been completely avoided at all cost and completely been monitored by author.

References

1. Boopathi S, Poma AB, Kolandaivel P. Novel 2019 coronavirus structure, mechanism of action, antiviral drug promises and rule out against its treatment. Journal of Biomolecular Structure and Dynamics. 2021 Jun 13;39(9):3409-18.

2. Sexton NR, Smith EC, Blanc H, Vignuzzi M, Peersen OB, Denison MR. Homology-based identification of a mutation in the coronavirus RNA-dependent RNA polymerase that confers resistance to multiple mutagens. Journal of virology. 2016;90(16):7415-28.

3. Vardavas CI, Nikitara K. COVID-19 and smoking: A systematic review of the evidence. Tobacco induced diseases. 2020;18.

4. Luo J, Rizvi H, Preeshagul IR, Egger JV, Hoyos D, Bandlamudi C, et al. COVID-19 in patients with lung cancer. Annals of Oncology. 2020;31(10):1386-96.

5. Callaway E. Gene Variants Linked to Covid Risk. Nature. 2021:346-8.

6. Wang Z, Zhou Y, Zhang Y, Huang X, Duan X, Chen D, et al. Association of change in air quality with hospital admission for acute exacerbation of chronic obstructive pulmonary disease in Guangdong, China: A province-wide ecological study. Ecotoxicology and Environmental Safety. 2021;208:111590.

7. Seposo X, Arcilla ALA, De Guzman JGN, Dizon EMS, Figuracion ANR, Morales CMM, et al. Ambient air quality and the risk for Chronic Obstructive Pulmonary Disease among Metro Manila Development Authority traffic enforcers in Metro Manila: An exploratory study. Chronic Diseases and Translational Medicine. 2021;7(2):117-24.

8. Wiegman CH, Li F, Ryffel B, Togbe D, Chung KF. Oxidative stress in ozone-induced chronic lung inflammation and emphysema: a facet of chronic obstructive pulmonary disease. Frontiers in Immunology. 2020:1957.

9. Wu X, Zhu B, Zhou J, Bi Y, Xu S, Zhou B. The epidemiological trends in the burden of lung cancer attributable to $PM_{2.5}$ exposure in China. BMC public health. 2021;21(1):1-8.

10. Wikipedia. Air quality index: wikipedia; 2022 [cited 2022 03/02/2022]. Available from: https://

en.wikipedia.org/wiki/Air_quality_index.

11. Zibran MF. Chi-squared test of independence. Department of Computer Science, University of Calgary, Alberta, Canada. 2007:1-7.

12. Acock AC, Stavig GR. A measure of association for nonparametric statistics. Social Forces. 1979;57(4):1381-6.

13. Yazici B, Yolacan S. A comparison of various tests of normality. Journal of Statistical Computation and Simulation. 2007;77(2):175-83.

14. Puth M-T, Neuhäuser M, Ruxton GD. Effective use of Pearson's product–moment correlation coefficient. Animal behaviour. 2014;93:183-9.

15. Sedgwick P. Spearman’s rank correlation coefficient. Bmj. 2014;349.

16. Severe Covid-19 GWAS Group. Genomewide association study of severe Covid-19 with respiratory failure. New England Journal of Medicine. 2020 Oct 15;383(16):1522-34.