Health Care Without Harm

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LUNG CARE FOUNDATION

# COVID-19 and Air Pollution

Recent studies regarding Air Pollution and COVID-19

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# Introduction

On late December 2019, a novel coronavirus infectious disease outbreak was identified in Wuhan, China named as COVID-19 increasing rapidly and the outbreak turned into epidemic.

It was then confirmed by World Health Organization (WHO) that the spread was through human to human transmission of COVID-19 through respiratory droplets.

**Recent news**

The World Health Organization (WHO) on early July 2020 acknowledged "evidence emerging" of the airborne spread of the novel coronavirus

https://health.economictimes.indiatimes.com/news/industry/who-acknowledges-evidence-emerging-of-airborne-spread-of-covid-19/76847993

The Hindu Explains | Is airborne transmission of COVID-19 a risk?

ET Healthworld.com From The Economic Times

**WHO acknowledges 'evidence emerging' of airborne spread of COVID-19**

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# Study-1

## Exposure to air pollution and COVID-19 mortality in the United States: A nationwide cross-sectional study (HARVARD study)

**Objectives:** To investigate whether long-term average exposure to fine particulate matter (PM2.5) is associated with an increased risk of COVID-19 death in the United States.

Exposure to air pollution and COVID-19 mortality in the United States: A nationwide cross-sectional study Xiao Wu, Rachel C Nethery, M Benjamin Sabath, Danielle Braun, Francesca Dominici

https://projects.iq.harvard.edu/files/covid-pm/files/pm_and_covid_mortality_med.pdf

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# METHODOLOGY

A nationwide, cross-sectional study using county-level data

**COVID 19 death counts:** More than 3,000 counties in the United States up to April 22, 2020

# RESULTS

Statistically significant evidence that an increase of 1 $\mu$g/m3 in long-term PM2.5 exposure is associated with an 8% increase in the COVID-19 mortality rate.

# CONCLUSIONS

First nationwide study in the United States which indicated that a small increase in long-term exposure to PM2.5 leads to a large increase in the COVID-19 death rate

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# Study-2

## Links between air pollution and COVID-19 in England

**Objectives:** Explore the relationship between air pollution and COVID-19 using an approach that combines both population- and individual-level data

Links between air pollution and COVID-19 in England
Marco Travaglio, Yizhou Yu, Rebeka Popovic, Liza Selley, Nuno Santos Leal, L. Miguel Martins
doi: https://doi.org/10.1101/2020.04.16.20067405

https://www.medrxiv.org/content/10.1101/2020.04.16.20067405v5

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# METHODOLOGY

| Data for COVID-19 deaths and cases | Data for air pollution levels | Subnational fossil fuel consumption data | Regional heatmaps | UK Biobank |
|---|---|---|---|---|
| • COVID-19 cases and deaths (regional, subregional) | • Nitrogen dioxide, nitrogen oxide and ozone air quality (AQ) values based on direct observations (2018 to 2019) | • Road transport, residual fuel; and annualized and weather-corrected gas consumption | • Regions were labelled with the mapped color values | • Distribution and infectivity data |

# RESULTS

- Nitrogen dioxide, nitrogen oxide and ozone levels are significant predictors of COVID-19 related death.
- SARS-CoV-2 cases and deaths are associated with regional variations in air pollution across England.

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# RESULTS

## At Subregional level

1 µg/m3 increase in the Sulphur dioxide concentration

- 17.2% more deaths (Mortality rate ratio of 1.172 [95% confidence interval (CI): 1.005-1.369])
- 31.6% more cases (Infectivity rate ratio of 1.316 [95% CI: 1.141 - 1.521])

## At Individual level

PM2.5 and PM10

- Significant predictors of increased SARS-CoV-2 infectivity

PM2.5: odds ratios 1.120 [CI: 1.036 - 1.211]

PM10: 1.074 [CI: 1.017 - 1.136]

Fossil fuel emission levels are linked to pollutants that contribute to increased numbers of COVID-19 deaths

# CONCLUSIONS

- Associations between air pollution and COVID-19 deaths and cases in England
- Exposure to poor AQ increases the risks of COVID- 19 infection and mortality in the UK

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# Study-3

## Association between environmental pollution and prevalence of coronavirus disease 2019 (COVID-19) in Italy

**Aim:** Explore the potential epidemiological association between the number of cases of COVID-19 and environmental pollution in Italy.

Association between environmental pollution and prevalence of coronavirus disease 2019 (COVID-19) in Italy
Authors: Giuseppe Lippi , Fabian Sanchis-Gomar, Brandon M. Henry

https://www.medrxiv.org/content/10.1101/2020.04.22.20075986v1.full.pdf

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# METHODOLOGY

- Environmental pollution data were retrieved from the 2019 annual report of the organization Legambiente (League for the Ambient)
- Positive COVID-19 cases per province was captured from the daily statics

# RESULTS

Highly significant positive association (r=0.66; 95% CI, 0.48-0.79; p<0.001)
Number of days above pollutant limits and the overall number of COVID-19 cases

Correlation was statistically significant between the number of days above pollutant limits and number of COVID-19 cases per 1000 inhabitants (r=0.43; 95% CI, 0.18-0.62; p=0.001)

Risk of being COVID-19 positive is 3 times higher among those living over 100 days per year in which environmental pollutants were exceeded (0.014 vs. 0.005 COVID-19 cases per 1000 inhabitants; OR, 2.96; 95% 2.12-4.13; p<0.001)

# CONCLUSIONS

Significant correlation between the number of COVID-19 cases and environmental pollution in Italy

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# Study-4

## Role of the chronic air pollution levels in the Covid-19 outbreak risk in Italy

**Hypothesis:** Atmospheric pollution may influence theSARS-CoV-2 outbreak in Italy

Role of the chronic air pollution levels in the Covid-19 outbreak risk in Italy
DanieleFattorini, FrancescoRegoli

http://www.sciencedirect.com/science/article/pii/S0269749120332115

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# METHODOLOGY

- Regional distribution of Covid-19 outbreak in Italy (from February 24 to April 27, 2020)
- Regional data on air quality levels (2016-2019): NO2, PM2.5 and PM10
- Number of days per year exceeding the regulatory limits (2017-2019): ozone, PM10
- Number of years (2010-2019) in which the PM10 limit was exceeded for at least 35 days per year

# RESULTS

Chronicity of exposure may influence the anomalous variability of SARS-CoV-2 in Italy

Long term exposure to atmospheric contamination may represent a favourable context for the spread of the virus.

# CONCLUSIONS

Atmospheric and environmental pollution should be considered as part of an integrated approach for sustainable development, human health protection and prevention of epidemic spreads.

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# Study-5

## Association between short-term exposure to air pollution and COVID-19 infection: Evidence from China

**Aim:** Explore the relationship between ambient air pollutants and the infection caused by the novel coronavirus

Association between short-term exposure to air pollution and COVID-19 infection: Evidence from China
YongjianZhu, JinguiXie, FengmingHuang, LiqingCao

https://www.sciencedirect.com/science/article/pii/S004896972032221X#s0010

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# METHODOLOGY

Daily confirmed cases, air pollution concentration and meteorological variables in 120 cities in China
(January 23, 2020 - February 29, 2020)

# RESULTS

- Significant correlation between air pollutants (PM2.5, PM10, SO2, CO,NO2 and O3)
- Correlation seen between air pollutants and mean temperature and relative humidity
- Positive correlation between PM2.5 and NO2 with air pressure
- Except SO2, all pollutants were significantly correlated with wind speed

- Significantly positive associations of PM2.5, PM10, CO,NO2 and O3 with COVID-19 confirmed cases
- SO2 was negatively associated with COVID-19 confirmed cases

# CONCLUSIONS

Significant relationship between air pollution and COVID-19 infection.
Exposure to PM2.5, PM10, CO, NO2 and O3 at any concentrations is associated with an increased risk of COVID-19 infection

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# Study-6

## Effects of temperature variation and humidity on the death of COVID-19 in Wuhan, China

**Aim:** Explore the association between Corona Virus Disease 2019 (COVID-19) deaths and weather parameters

Effects of temperature variation and humidity on the death of COVID-19 in Wuhan, China
Yueling Ma, Yadong Zhao, Jiangtao Liu, Xiaotao He, BoWang, Shihua Fu, Jun Yan, Jingping Niu, Ji Zhou, Bin Luo

http://www.sciencedirect.com/science/article/pii/S0048969720317393

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# METHODOLOGY

Daily death numbers of COVID-19, meteorological parameters and air pollutant data
(20 January 2020 - 29 February 2020)

# RESULTS

2299 COVID-19 deaths and 56 deaths of COVID-19 per day

**Correlation with COVID-19 daily death counts**

Positive association for diurnal temperature range (DTR) (r = 0.44)
Negative association for relative humidity (r = −0.32)

**One unit increase**

- **Diurnal temperature range:** 2.92% (95% CI: 0.61%, 5.28%) increase in COVID-19 deaths in lag 3
- **Temperature and absolute humidity:** decreased COVID-19 death in lag 3 and lag 5, with the greatest decrease both in lag 3

# CONCLUSIONS

- Daily mortality of COVID-19 is positively associated with DTR but negatively with absolute humidity
- The effects of DTR and humidity important factor affecting COVID-19 mortality

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# Study-7

## Effect of restricted emissions during COVID-19 on air quality in India

The effect of restricted human activities due to the COVID-19 pandemic in India on air quality in 22 cities

Effect of restricted emissions during COVID-19 on air quality in India
ShubhamSharma, MengyuanZhang, Anshika, JingsiGao, HongliangZhang, Sri HarshaKota
http://www.sciencedirect.com/science/article/pii/S0048969720323950

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# METHODOLOGY

Data from March 16th to April 14th from 2017 to 2020 in 22 cities of India:

- Concentrations of PM10, PM2.5, CO, NO2, ozone and SO2
- Meteorological parameters including wind speed, wind direction, temperature and relative humidity

# RESULTS

Decrease of pollutant during lockdown period

| | |
|---|---|
| PM2.5: 43% | CO: 10% |
| PM10: 31% | NO2: 18% |

- PM2.5 had maximum reduction in most regions
- Correlation between cities especially in northern and eastern regions improved in 2020 compared to previous years
- The substantial reduction in concentrations resulted in a 4 times reduction in total excessive risks

# CONCLUSIONS

A significant improvement in air quality in India could be expected if strict execution of air quality control plans is implemented.

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# Study-8

## Effect of lockdown amid COVID-19 pandemic on air quality of the megacity Delhi, India

**Objectives:** (i) Compare the atmospheric pollutant concentrations in Delhi during the pre and during lockdown periods

(ii) Quantify the integrated air quality due to the implementation of lockdown regulation during lockdown periods

(iii) Unveil the level of major pollutant concentration in the past few years during the same window period

Effect of lockdown amid COVID-19 pandemic on air quality of the megacity Delhi, India
Susanta Mahato, Swades Pal, Krishna Gopal Ghosh

http://www.sciencedirect.com/science/article/pii/S0048969720326036

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# METHODOLOGY

- **Study area:** Delhi
- The daily or hourly concentration of PM2.5 and PM10, SO2, NO2, CO, O3 and NH3 from 34 air quality monitoring stations covering different regions of the megacity

# RESULTS

During lockdown air quality significantly improved:

1. Reduction of air pollutants: PM10 and PM2.5: >50%, NO2: −52.68% and CO: −30.35%
2. Transportation and industrial location: close to 60%
3. On the 2nd and 4th day of lockdown: 40% to 50%
4. 54%, 49%, 43%, 37% and 31% reduction in NAQI: Central, Eastern, Southern, Western and Northern parts of the megacity respectively

# CONCLUSIONS

- Improvement in air quality due to lockdown a useful supplement to the regulatory bodies
- Temporary such source control in a suitable time interval may heal the environment.

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# Study-9

## Impact of COVID-19 related shutdown on atmospheric carbon dioxide level in the city of Kolkata

To scan the air quality change during the lockdown phase of COVID-19 in the city of Kolkata (India) on 2nd April, 2020 and compare the same with the data of April, 2019, when the COVID -19 outbreak was not visualized

Impact of COVID-19 related shutdown on atmospheric carbon dioxide level in the city of Kolkata
Abhijit Mitra, Tanmay Ray Chaudhuri, Ankita Mitra, Prosenjit Pramanick and Sufia Zaman
https://www.researchgate.net/publication/340661771_Impact_of_COVID19_related_shutdown_on_atmospheric_carbon_dioxide_level_in_the_city_of_Kolkata

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# METHODOLOGY

Atmospheric carbon dioxide concentrations at 12 different sites of the city of Kolkata measured with a portable $CO_2$ analyzer (Lutron $CO_2$ meter, GCH-2018) during the afternoon hours

(April, 2019- period before lockdown and April, 2020- under the lockdown phase)

# RESULTS

Significant temporal variation of $CO_2$ level ($p < 0.01$), but no statistically significant variation between sites

# CONCLUSIONS

The regulatory influence of COVID-19 connected lockdown in slashing down the $CO_2$ level in the urban atmosphere

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# Study-10

## Ambient nitrogen dioxide pollution and spread ability of COVID-19 in Chinese cities

**Aim:** To assess the associations of ambient NO2 levels with spread ability of COVID-19 across 63 Chinese cities, and provides information for the further prevention and control of COVID-19.

Ambient nitrogen dioxide pollution and spread ability of COVID-19 in Chinese cities
Ye Yao, Jinhua Pan, Zhixi Liu, Xia Meng, Weidong Wang, Haidong Kan, Weibing Wang

https://www.medrxiv.org/content/10.1101/2020.03.31.20048595v2

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# METHODOLOGY

- COVID-19 confirmed case information
- Calculated basic reproduction number (R0) for 63 cities with more than 50 cases as of February 10
- Hourly NO2 data: Daily concentrations of NO2 were calculated as the average of at least 18 (75%) hourly concentrations for all state-controlled stations, then daily NO2 levels of the city was averaged from all valid stations within it.
- Meteorological data including daily mean temperature and relative humidity

# RESULTS

After adjustment for temperature and humidity, the R0 was positively associated with NO2 in all cities

No signification associations of temperature and relative humanity with R0 of COVID-19

A significant association was confirmed in the cities outside of Hubei ($r=0.29$, $p=0.046$), while it is not the case in the cities inside Hubei ($r=0.51$, $p=0.130$)

11 Hubei cities all held significant positive correlations between NO2 (with 12-day time lag) and R0 ($r>0.51$, $p<0.005$), suggesting a positive association between NO2 and COVID-19 spread ability in the temporal scale.

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# CONCLUSIONS

First study to investigate the ambient air pollution associated with the transmission of COVID-19.
The results reported the significant association between NO2 exposure and R0, suggesting that ambient NO2 may contribute to the spread ability of COVID-19.

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# Study-11

## COVID-19 higher induced mortality in Chinese regions with lower air quality

Investigate whether there is a correlation between air pollution and air-borne SARS-CoV-2 causing respiratory diseases in China, Italy and the United States.

COVID-19 higher induced mortality in Chinese regions with lower air quality
Riccardo Pansini & Davide Fornacca

https://www.medrxiv.org/content/10.1101/2020.04.04.20053595v2.full.pdf

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# METHODOLOGY

| | Measuring Unit |
|---|---|
| **COVID-19** | |
| Italy<br>China<br>U.S.A. | No. of cases<br>No. of cases and deaths<br>No. of cases and deaths |
| **Population** | |
| Italy<br>China<br>U.S.A. | No. of residents |
| **Air Quality (ground measures)** | |
| Italy (PM2.5, PM10)<br>China (PM2.5, PM10, O3, NO2, SO2, CO)<br>U.S.A. (PM2.5, PM10, O3, NO2, SO2, CO) | ug/m3<br>AQI<br>ug/m3 ppm, ppb |
| **Air Quality (satellite)** | |
| UV Aerosol Index<br>CO<br>HCHO<br>NO2<br>O3<br>SO2 | Qualitative Index<br>mol/m^2<br>mol/m^2<br>mol/m^2<br>mol/m^2<br>mol/m^2 |

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# RESULTS

### Comparison of satellite-derived data with ground measures

- Strongest correlation was found in the NO2 values, both in China and in the U.S.A.
- In both countries (China and U.S.A.), the Ozone values did not show a significant correlation.
- Carbon Dioxide and SO2 also showed significant agreement in China, while in the U.S.A. no correlation was found for SO2.

### COVID-19 cases and air quality maps

- The highest values are found in more polluted areas.
- Italy faces a more critical problem of NO2 pollution during the year 2019, relative to its size

### Correlation between air pollution variables with COVID-19 infections and mortality

- Significant correlation between levels of air quality and COVID-19 spread and mortality in China, Italy and the United States
- In China, the strongest correlation was CO values
- In Italy and the U.S.A., the highest values were those of NO2
- CO, Formaldehyde, PM2.5, NO2 were positively correlated with COVID-19 cases
- Ozone shows a relatively strong positive correlation in Italy while it is negative in China and the U.S.A.
- Clear positive correlation with air quality variables, in particular with PM2.5 and CO in China, and with CO and NO2 in the U.S.A

# CONCLUSIONS

- Significant correlation between levels of air quality and COVID-19 spread and mortality in China, Italy and the United States.
- Living in an area with low air quality seems to be a risk factor for becoming infected and dying from this new form of coronavirus.

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# Study-12

# Temporal Association Between Particulate Matter Pollution and Case Fatality Rate of COVID-19 in Wuhan, China

**Aim:** To investigate the temporal association between CFR of COVID-19 and PM in Wuhan

**Temporal Association Between Particulate Matter Pollution and Case Fatality Rate of COVID-19 in Wuhan, China**
Ye Yao, Jinhua Pan, Zhixi Liu, Xia Meng, Weidong Wang, Haidong Kan, Weibing Wang
https://www.medrxiv.org/content/10.1101/2020.04.09.20049924v1.full.pdf

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# METHODOLOGY

- COVID-19 confirmed cases and deaths information
- Daily fine particulate matter (PM2.5), inhalable particulate matter (PM10), and meteorological data including daily mean temperature and relative humidity

# RESULTS

COVID-19 held higher case fatality rate with increasing concentrations of PM2.5 and PM10 in temporal scale

After further adjustment for time effects, Case Fatality Rate of COVID-19 still held a strong positive association with concentrations of PM2.5 and PM10

# CONCLUSIONS

As COVID-19 held higher case fatality rate with increasing concentrations of PM2.5 and PM10 in temporal scale, which may affect the process of patients developed from mild to severe and 29 finally influence the prognosis of COVID-19 patients

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# Study-13

## Air Pollution Exposure and COVID-19

Estimate the relationship between long term air pollution exposure and Covid-19 in 355 municipalities in the Netherlands

Air Pollution Exposure and COVID-19 JUNE 2020
Matthew A. Cole, Ceren Ozgen and IZA Eric Strobl
http://ftp.iza.org/dp13367.pdf

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# METHODOLOGY

- Detailed secondary and administrative data was used
- Covid-19 data
- Annual concentrations of PM2.5, NO2, and SO2

# RESULTS

### PM2.5 concentrations

- Positive and statistically significant relationship with Covid-19 cases, hospital admissions and deaths.
- 1 unit increase in PM2.5 concentrations is associated with
  - ✓ 9.4 more Covid-19 cases
  - ✓ 3.0 more hospital admissions
  - ✓ 2.3 more deaths.

### NO2

- Positive and statistically significant association between Covid-19 cases and deaths, but not statistically significant for hospital admissions.
- 1 unit increase in NO2
  - ✓ increases Covid-19 cases by 2.2 and deaths by 0.35.

### SO2

Statistically significant for Covid-19 deaths.

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One standard deviation increase PM2.5 and NO2 concentrations increases Covid-19 cases by 12.7 and 8.6,

One standard deviation in PM2.5 and NO2 concentrations increases Covid-19 deaths by 3.0 and 1.4,

# CONCLUSIONS

- Statistically significant positive relationship between air pollution and Covid-19 cases, hospital admissions and deaths.
- Relationship is evident for PM2.5 and to a lesser extent NO2 and persists even after controlling variables.