Long-term exposure to air-pollution and COVID-19 related mortality

Garyfallos Konstantinoudis

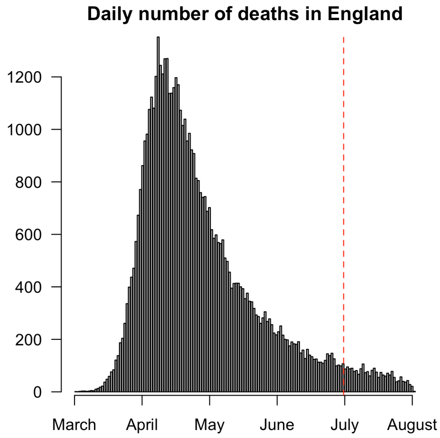
MRC Centre of Environment and Health

Outline

Introduction

COVID-19 in the UK

- WHO announced COVID-19 outbreak as a pandemic on 11 March 2020.
- In the UK 40,000 deaths.
- Age, sex, ethnicity.
- Diabetes, COPD, hypertension etc.
- Sparked discussion about air-pollution.



Previous studies

Authors	**Country**	**Pollutants**	**Effect**
Oregom 2020	EU	NO_2	83% of the fatalities $NO_2 > 100\mu mol/m^2$
Wu 2020	US	$PM_{2.5}$	8% (2%, 15%) $1\mu g/m^3$
Travaglio 2020	England	NO_2, NO, O_3	NO_2 ($p<0.05$)
Liang 2020	US	NO_2, $PM_{2.5}$, O_3	NO_2: 11.2% (3.4%, 19.5%) per $5.625\mu g/m^3$ $PM_{2.5}$: 10.8% (-1.1%, 24.1%) per $3.4\mu g/m^3$
Cole 2020	Netherlands	NO_2, $PM_{2.5}$, SO_2	NO_2: 0.35 deaths for $1\mu g/m^3$ $PM_{2.5}$: 2.3 deaths for $1\mu g/m^3$

Limitations of previous studies

- Large spatial units: Oregon EU countries, Travaglio 317 LTLAs, Wu & Liang 3,122 counties, Cole: 335 municipalities.
  - Exposure varies on high resolution.
  - Insufficient adjustment for confounding.
  - Ecological bias
- Previous studies were in early stages of the epidemic.
- Lack of spatial component.

Aim

Examine the effect of $PM_{2.5}$ and NO_2 (independently) on COVID-19 related mortality:

- Propose a model to downscale the COVID-19 related deaths from LTLAs to LSOA using information on population density, age, sex and ethnicity.
- Use the downscaled COVID-19 related deaths and examine the effect of $PM_{2.5}$ and NO_2.

Methods

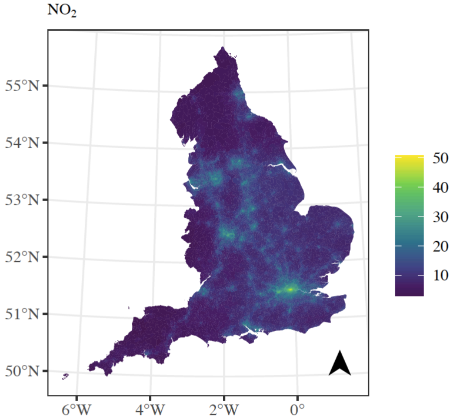
Outcome and Exposure

Outcome

- Public Health England.
- COVID-19 deaths from PHE until June 30.
- Confirmed COVID-19 related deaths.

Exposure

- Pollution Climate Mapping (R^2 =0.88 for NO_2 and R^2 = 0.63 for $PM_{2.5}$).
- Long term exposure: Past 5 years (2014-2018).

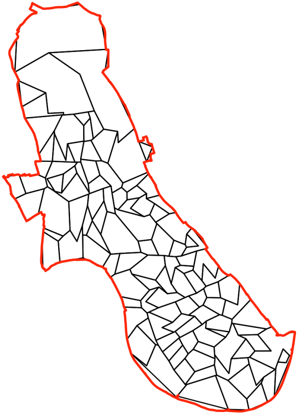


Confounding

Covariates	Source	Spatial resolution
Temperature	MetOffice	$1km^2$
Relative humidity	MetOffice	$1km^2$
Deprivation	IMD	LSOA
Age	PHE & ONS	ind for deaths, LSOA
Sex	PHE & ONS	ind for deaths, LSOA
Ethnicity	PHE & ONS	ind for deaths, LSOA
Urbanicity	ONS	OA & SOA
Days since 1st case reported	testing data	LTLA
# of positive cases	testing data	LTLA
Population density	ONS	LSOA
Critical Care Bed Capacity	NHS England	NHS Trust
Smoking	PHE	GP catchment areas
Obesity	PHE	GP catchment areas

Epidemiological model: Disaggregation

- COVID-19 deaths available at LTLA.
- i age, j sex, k ethnicity and l the set of LSOAs in one LTLA.
- Calculate $p_{ijkl} = N_{ijkl} / \sum_l N_{ijkl}$ for every l.
- Weighted sample (p_{ijkl}) with replacement.
- Perform 100 times and propagate the uncertainty.



Epidemiological model

Let $\mathcal{W}$ an observation window, $A_1, ..., A_N$ a partition, Y_i be the COVID-19 deaths, E_i the expected and λ_i the risk in A_i:

$$Y_i|\lambda_i, E_i \sim \text{Poisson}(\lambda_i E_i)$$

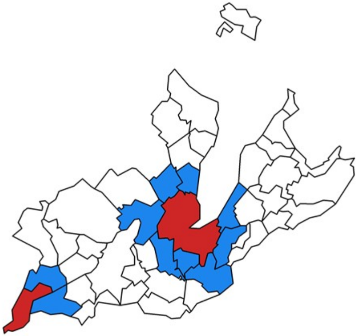
$$\log(\lambda_i) = \beta_0 + \alpha x_i + \boldsymbol{z}_i^T \boldsymbol{\beta} + u_i + v_i$$

$$u_i|\mathbf{u}_{-i} \sim \mathcal{N}\Big(\frac{\sum_{j=1}^N w_{ij} u_j}{\sum_{j=1}^N w_{ij}}, \frac{1}{\tau_1 \sum_{j=1}^N w_{ij}}\Big)$$

$$v_i \sim \mathcal{N}(0, \tau_2^{-1})$$

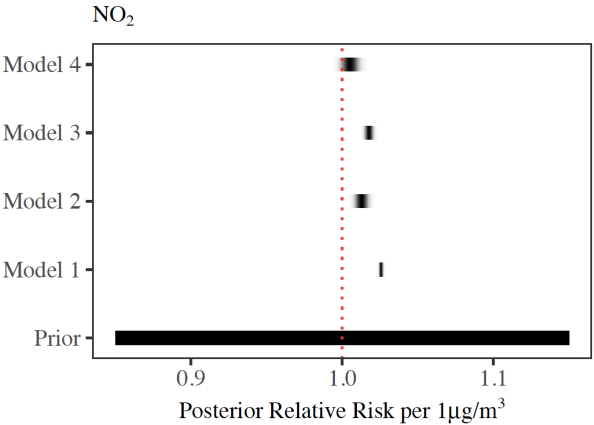
$$\beta_0, \alpha, \boldsymbol{\beta} \sim \mathcal{N}(0, \sigma^2)$$

$$\tau_1, \tau_2 \sim \text{PCpriors}$$

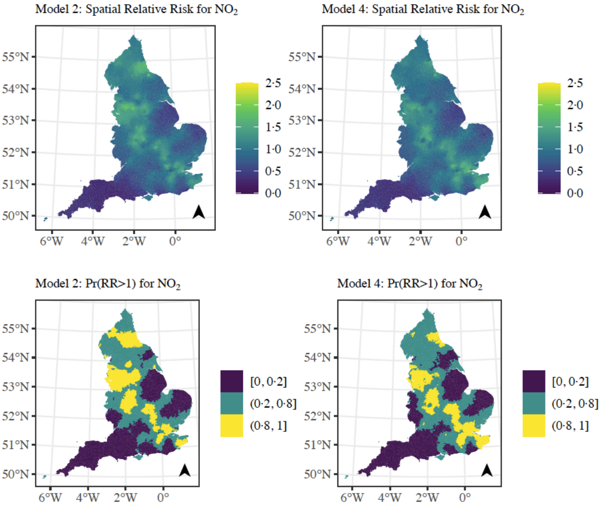


Results

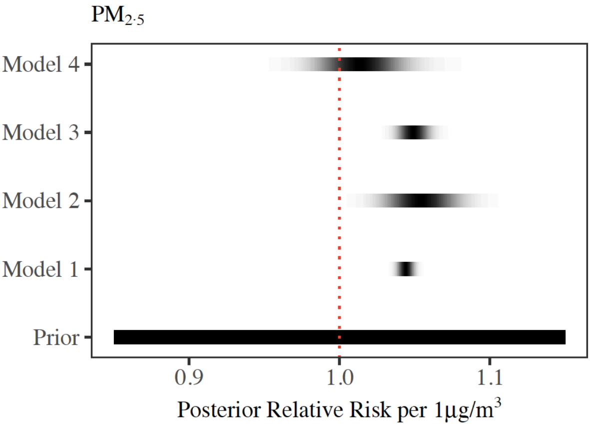
Epidemiological model for NO_2: Main effect



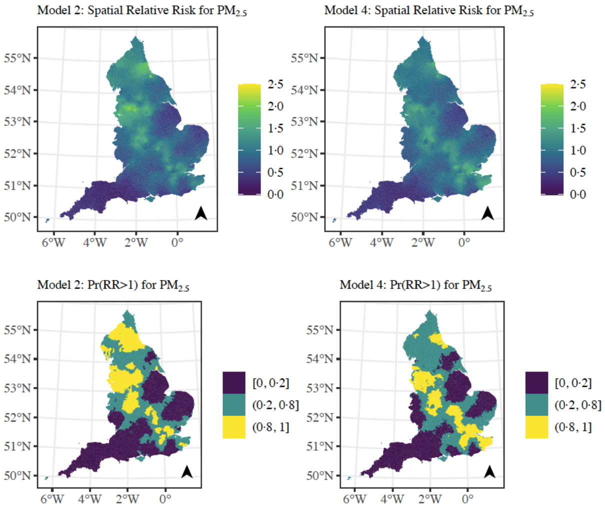
Epidemiological model for NO_2: spatial relative risk



Epidemiological model for $PM_{2.5}$: Main effect



Epidemiological model for $PM_{2.5}$: Spatial Relative Risk



Discussion

Summary of the results

- 2.6% (2.4%-2.7%) for every unit increase in NO_2.
- 4.4% (3.7%-5.1%) for every unit increase in $PM_{2.5}$.
- Weak effect after adjusting for confounders and spatial autocorrelation.
- The latent field unaffected and potentially captures disease spread.

In context with previous studies for NO_2

- Travaglio et al 2020, England: increased COVID-19 mortality ($p<0.05$).
- Liang et al 2020, US: 7.1% (1.2%, 13.4%) increased COVID-19 mortality for $5.625\mu g/m^3$ increase in NO_2
- Cole et al 2020, Netherlands: 2% increased COVID-19 mortality for $1\mu g/m^3$ increase in NO_2.
- We found 2.6% (2.4%-2.7%) in the unadjusted and 0.5%(-0.2% - 1.2%) in the fully adjusted.

In context with previous studies for $PM_{2.5}$

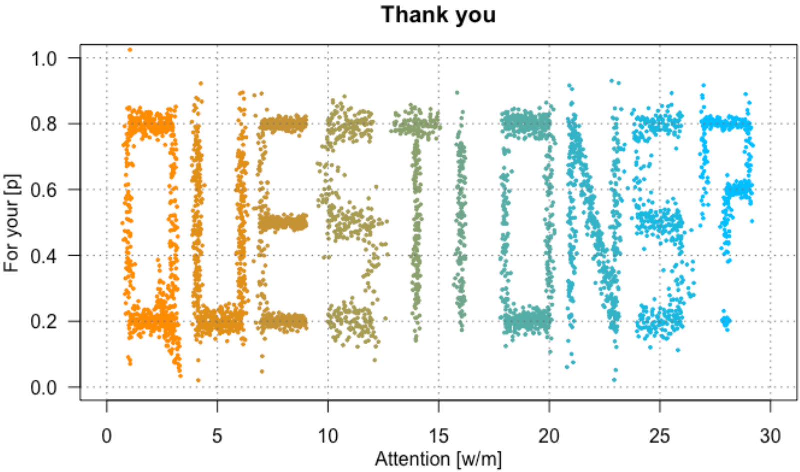
- Wu et al 2020, US: 8% (2%, 15%) increased COVID-19 mortality for $1\mu g/m^3$ increase in $PM_{2.5}$.
- Liang et al 2020, US: 10.8% (-1.1%, 24.1%) increased COVID-19 mortality for $3.4\mu g/m^3$ increase in $PM_{2.5}$.
- Cole et al 2020, Netherlands: 13.0% increased COVID-19 mortality for $1\mu g/m^3$ increase in $PM_{2.5}$.
- We found 4.4% (3.7%-5.1%) in the unadjusted and 1.4% (-2.1%-5.1%) in the fully adjusted.

Conclusion

- Weak evidence of an association between air-pollution and COVID-19 mortality.
- Effect of previous studies might be confounded with disease spread.

Take home message

Given the lack of individual exposure and pre-existing conditions data, our analysis is suggestive of a weak, if any, association of long-term average exposure to NO_2 and $PM_{2.5}$ on COVID-19 mortality.


Thank you
For your [p]
1.0
0.8
0.6
0.4
0.2
0.0
0
5
10
15
20
25
30
Attention [w/m]