Warm temperatures and COPD hospitalisations in England: A nationwide case-crossover study during 2007-2018.

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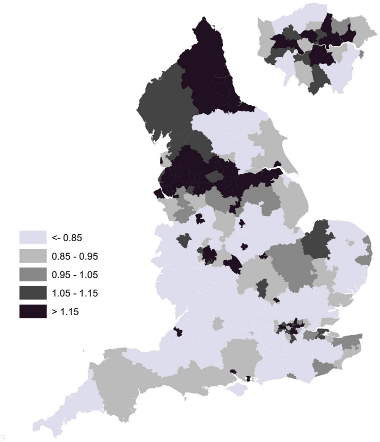
Outline

Introduction

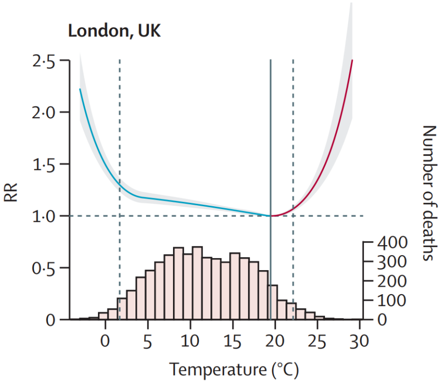
COPD burden

- 3^{rd} cause of death, 3.17 million deaths in 2015 globally.
- In England, 115,000 emergency admissions and 24,000 deaths per year.
- COPD exacerbations: Bacteria, viruses and air-pollution.
- The role of temperature is unclear.



Temperature

- Typically U-shaped relationship between temperature and health.
- Cold, dry air or hot air can trigger a flare-up.
- Different confounding, different lags across different temperatures.
- This study focuses on warm temperatures.



Previous studies

Authors	Aggregation	Country	Pollutants	Effect
Michelozzi 2009 et al	city & daily	EU	NO_2, O_3	2.1 (0.6 to 3.6) per 1^{o}C
Anderson et al 2013	county & daily	US	O_3, PM_{10}, $PM_{2.5}$	2.0 (0.4, 4.5) per 10^{o}F
Zhao 2019 et al	individual	Brazil	no adjustment	5.0 (4.0, 6.0) per 5^{o}C

- Spatial & temporal aggregation
  - Exposure varies on high resolution.
  - Insufficient adjustment for confounding (for instance physical activity).
  - Ecological bias
- One study individual data, but did not adjust for air-pollution

Aim

Examine the effect of warm temperatures on COPD hospitalizations.

Secondary objectives:

- Examine effect modification by age, sex and space.
- Assess how contextual characteristics, such as green space, average temperature, deprivation and urbanicity affect population vulnerability.
- Calculate the number of COPD cases attributable to temperature.

Methods

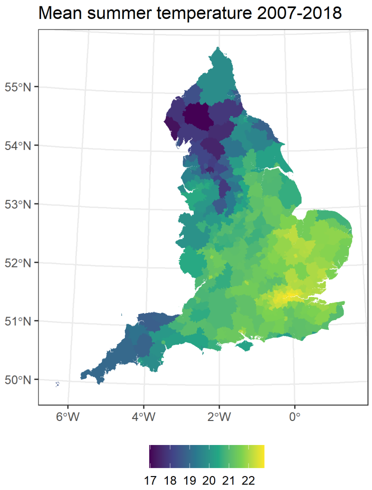
Outcome and Exposure

Outcome

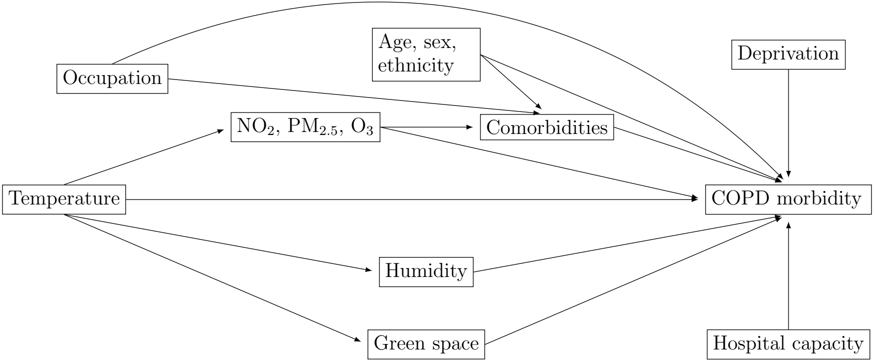
- NHS digital & SAHSU.
- COPD hospitalization (ICD10 J40-44) 2007-2018.
- Individual data/ 100m grid spatial resolution.
- Summer months.

Exposure

- Daily maximum temperature 2007-2018 at 1km grid from MetOffice.
- lag0-2.

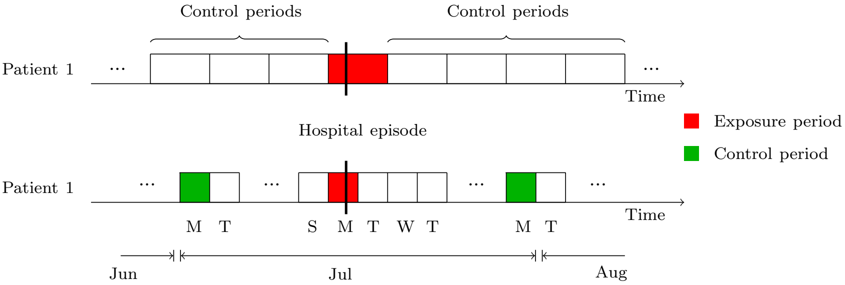


Confounding



Case cross-over design

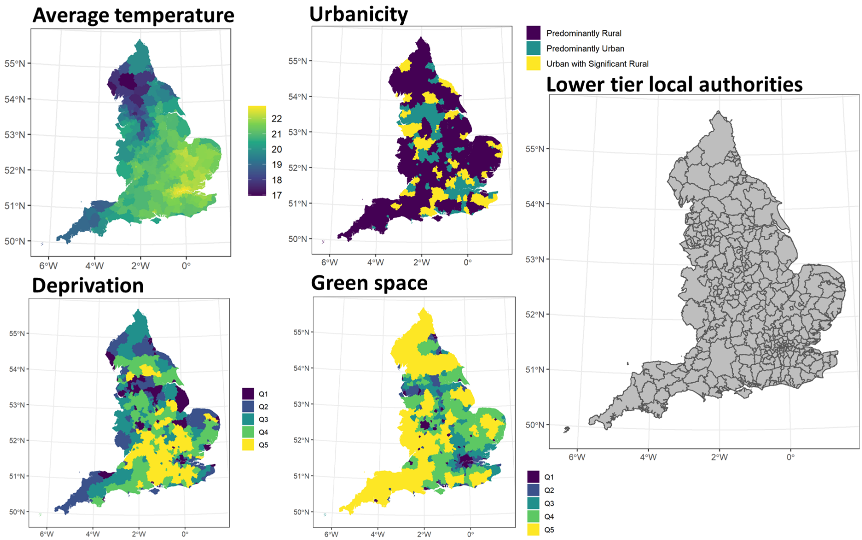
- Epidemiological study design for transient environmental exposures
- Sample from same month and days
- Exposure period 0-2 days before the hospital episode (mean temperature)



Confounding

Covariates	Source	Space	Time	years
$PM_{2.5}$	MetOffice	$1km^2$	daily	2007-2018
O_3	MetOffice	$1km^2$	daily	2007-2018
Relative humidity	MetOffice	$10km^2$	daily	2007-2018
Holidays	ONS	nationwide	daily	2007-2018

Spatial effect modifiers



Step 1. Find linear threshold

Let Y_{ij} be an indicator of the COPD hospitalization at time i (1-case, 0-control) of the j-th group of cases-controls, and μ_{ij} the risk ratio:

$$
\begin{aligned}
Y_{ij} &\sim \text{Poisson}(\mu_{ij}) \\
\log(\mu_{ij}) &= \alpha_1 I(X_{1i} < c_l)X_{1i} + \alpha_2 I(X_{1i} \geq c_l)X_{1i} + \\
&\qquad \sum_{m=1}^{4} \beta_m Z_{mi} + u_j \\
u_j &\sim N(0, 100) \\
\alpha_1, \alpha_2, \beta_1, \ldots \beta_4 &\sim N(0, 1)
\end{aligned}
$$

c is the temperature threshold, 50−th, 55−th, ..., 90−th, 95−th percentile. Calculate the WAIC for each.

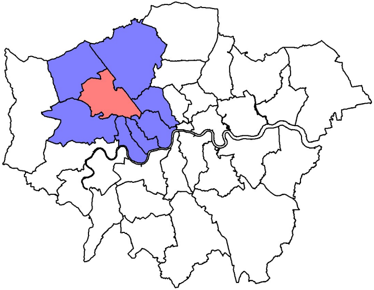
Step 2a. Effect modification by age and sex

We fitted the previous model for c_* that minimizes the WAIC for the different sex k and age g (<65, $65-85$, >85) subgroups.

$$
\begin{aligned}
Y_{ijgk} &\sim \text{Poisson}(\mu_{ijgk}) \\
\log(\mu_{ijgk}) &= \alpha_1 I(X_{1igk} < c_*) X_{1igk} + \alpha_2 I(X_{1igk} \geq c_*) X_{1igk} + \\
&\quad \sum_{m=1}^{4} \beta_m Z_{migk} + u_j \\
u_j &\sim N(0, 100) \\
\alpha_1, \alpha_2, \beta_1, \ldots \beta_5 &\sim N(0, 1)
\end{aligned}
$$

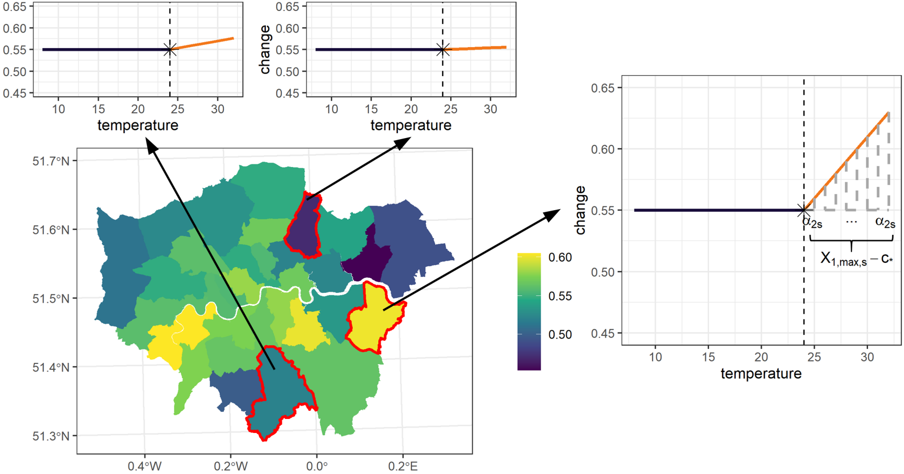
Step 2b. Spatial Effect modification

$$
\begin{aligned}
Y_{ij} &\sim \text{Poisson}(\mu_{ij}) \\
\log(\mu_{ij}) &= \alpha_1 I(X_{1i} < c_*)X_{1i} + \alpha_{2s} I(X_{1i} \geq c_*)X_{1i} + \\
&\qquad \sum_{m=1}^{4} \beta_m Z_{mi} + u_j \\
\alpha_{2s} &= \alpha_2 + \sum_{m=1}^{8} \gamma_m H_{sm} + v_s + b_s \\
v_s &\sim N(0, \sigma_1^2) \\
b_s | b_{-s} &\sim N\left(\frac{\sum_{s\sim r} w_{rs} b_s}{\sum_{s\sim r} w_{rs}}, \frac{\sigma_2^2}{\sum_{s\sim r} w_{rs}} \right)
\end{aligned}
$$



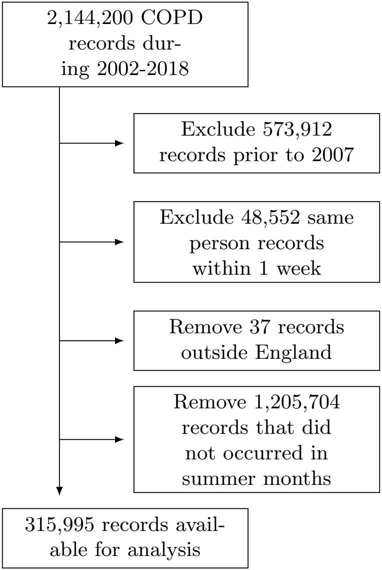
Population attributable fraction

1. Calculate $RR_s = \exp\left(\alpha_{2s}(X_{1,s,\max} - c_*)\right)$
2. Calculate $AF_s = (RR_s - 1)/RR_s$
3. Then $PAF_s = AF_s(N_s/N)$



Results

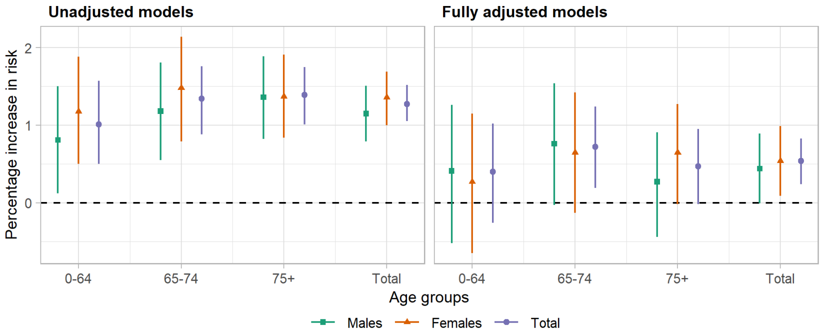
Flow chart


2,144,200 COPD records during 2002-2018
Exclude 573,912 records prior to 2007
Exclude 48,552 same person records within 1 week
Remove 37 records outside England
Remove 1,205,704 records that did not occurred in summer months
315,995 records available for analysis

Step 1: WAIC table

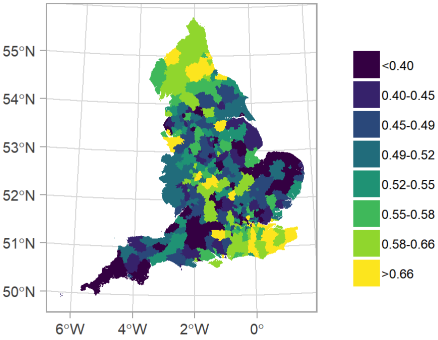
		Models unadjusted		Models fully adjusted	
Q	T (°C)	WAIC	Warm Effect	WAIC	Warm Effect
50	20.6	2,229,354	1.3 (1.0, 1.6)	2,228,899	0.49 (0.18, 0.84)
55	21.0	2,229,072	1.3 (1.0, 1.6)	2,228,749	0.50 (0.13, 0.84)
60	21.3	2,229,233	1.3 (1.0, 1.5)	2,228,673	0.46 (0.14, 0.80)
65	21.7	2,229,192	1.3 (1.0, 1.5)	2,228,693	0.45 (0.11, 0.78)
70	22.1	2,229,082	1.3 (1.0, 1.5)	2,228,755	0.48 (0.15, 0.81)
75	22.6	2,228,969	1.2 (1.0, 1.5)	2,228,682	0.41 (0.10, 0.72)
80	23.2	2,228,991	1.3 (1.0, 1.5)	2,228,613	0.50 (0.20, 0.81)
85	23.8	2,229,012	1.3 (1.0, 1.5)	2,228,610	0.53 (0.22, 0.84)
90	24.9	2,229,199	1.2 (1.0, 1.4)	2,228,628	0.43 (0.11, 0.76)
95	26.5	2,229,107	1.3 (1.0, 1.6)	2,228,687	0.55 (0.22, 0.88)

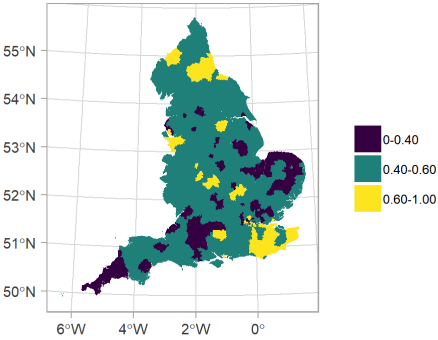
Step 2a: Effect modification by age and sex



Step 2a: Spatial effect modification

Results unadjusted for spatial effect modifiers



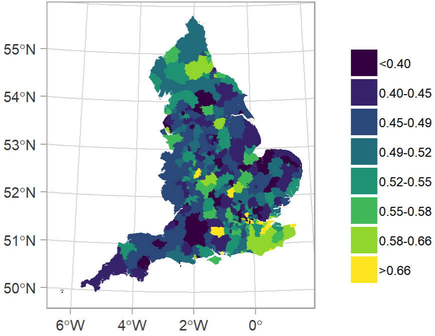


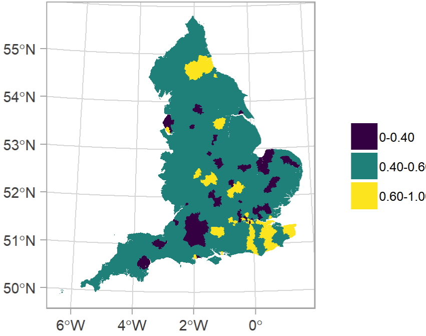
Step 2b: Spatial effect modification

Effect modifier	Percentage increase	Pr(Covariate>0)
Green space	-1.54 (-7.03, 4.17)	0.29
Average temperature	-0.42 (-1.47, 0.56)	0.21
IMD		
Q1	1	
Q2	0.77 (-1.30, 2.98)	0.78
Q3	1.31 (-1.05, 3.79)	0.86
Q4	0.44 (-2.09, 2.90)	0.63
Q5	0.96 (-1.88, 4.05)	0.77
Predominantly Rural	1	
Urban with significant rural	-1.67 (-4.39, 0.82)	0.34
Predominantly urban	-0.45 (-2.82, 1.88)	0.10

Step 2a: Spatial effect modification

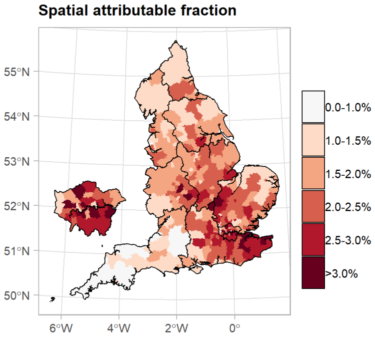
Results adjusted for spatial effect modifiers





Population attributable fraction

- 6,205 (3,528, 8,781) COPD hospitalisations attributable to warmer temperature
- 2.2% (1.3-3.1%) of the total COPD hospitalisations
- Populations in East Midlands, East of England, London and South East contribute most.



Discussion

Summary of the results

- Unadjusted: 1.2% (1.0%, 1.5%) for every 1^{o}C increase in warm temperatures.
- Adjusted: 0.53% (0.22%, 0.84%) for every 1^{o}C increase in warm temperatures.
- Weak evidence of an effect modification by sex and age.
- Strong spatial effect modification, with some evidence that populations in areas with more green space, higher average temperature and urbanicity are least vulnerable.

In context with previous studies

- Lin et al 2009, US: 7.64% increased COPD admissions for each 1 ^{o}C increase in daily mean apparent temperature above 32 ^{o}C.
- Michelozzi et al 2009, 12 EU cities: 4.5% (1.9–7.3) - 3.1% (0.8–5.5) increase in total respiratory admissions for 1^{o}C in the maximum apparent temperature (lag 0–3 days) above the 90th percentile.
- Anderson et al 2019, US: 4.7% (3.9, 5.5%) COPD hospitalisation rate at lag 0 for every 5.6 ^{o}C during May-September.
- Zhang et al 2020, Brazil: 5% (4, 6%) hospitalisation odds 0-3 lag for every 5 ^{o}C during 4 hottest months.

Strengths and limitations

Strengths

- Individual data.
- High geographical precision.
- Contextual characteristics.

Limitations

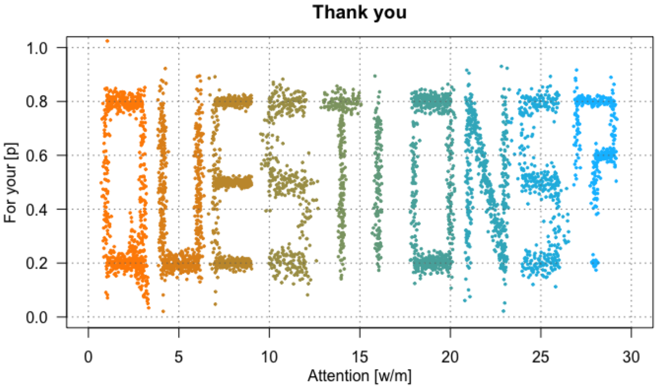
- Residential temperature does not reflect the actual temperature exposure.
- More complex relationships.

Conclusion

- Evidence COPD hospital admissions and maximum temperatures higher than 23.8°C during the summer months.
- Spatial vulnerabilities partly can be explained by green space, deprivation, urbanicity and average temperature.

Take home message

Evidence that COPD hospitalisations increase with warmer temperatures and as temperatures consistently increase, public health systems should be alerted and prepared to challenge the increased COPD hospitalisation burden.



github: `https://github.com/gkonstantinoudis/COPDTempSVC`

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Examples: `https://gkonstantinoudis.github.io/teaching/`

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