

Supplementary Material

Community-level risk factors for temperature-related mortality in France

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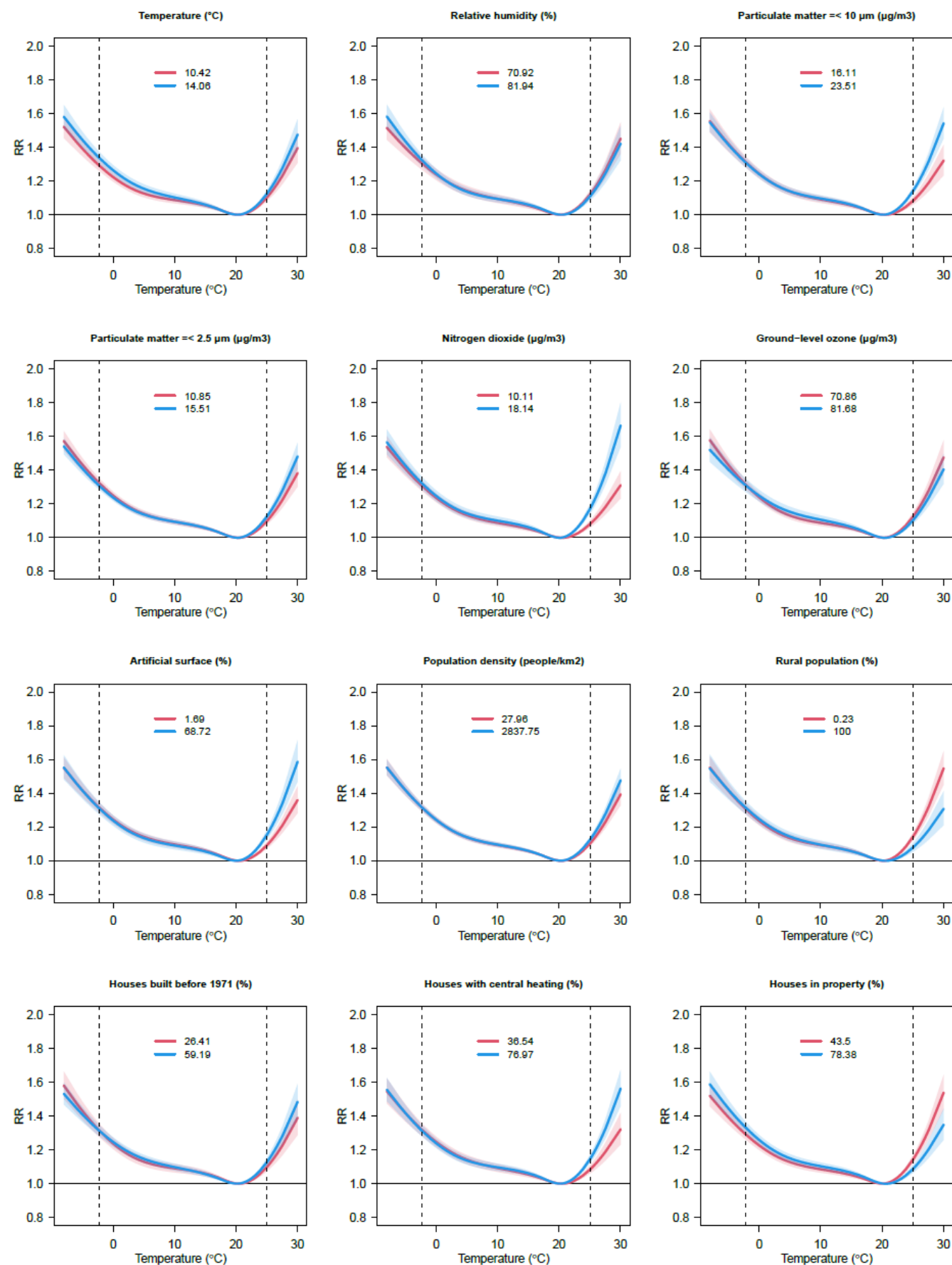
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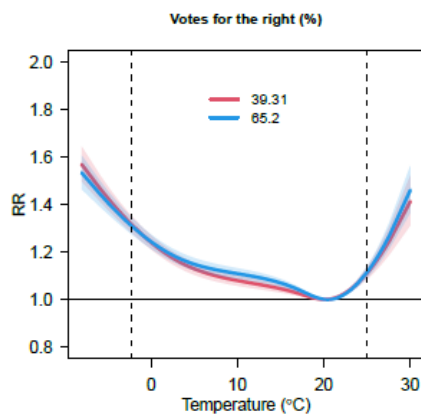
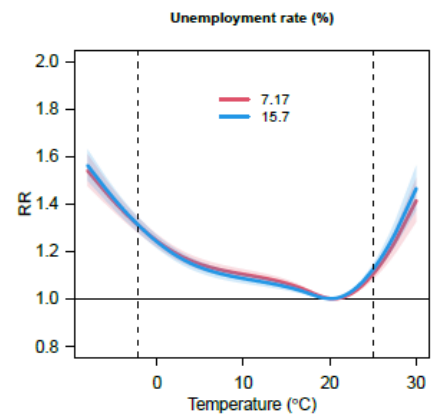
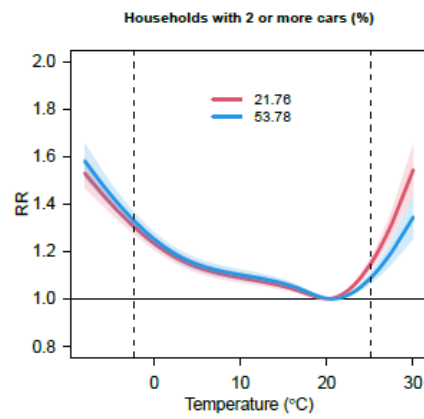
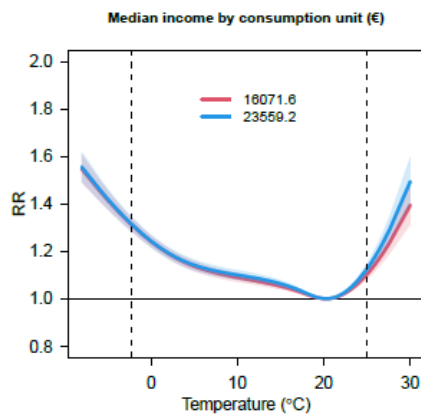
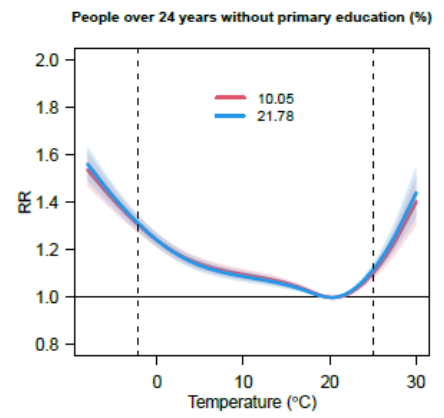
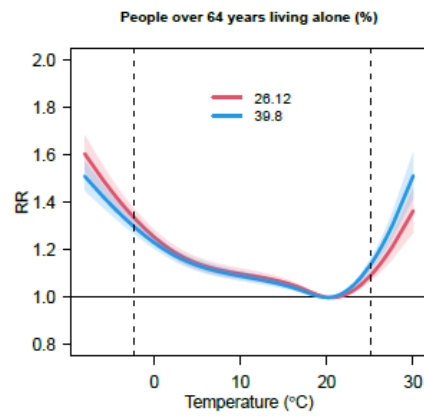
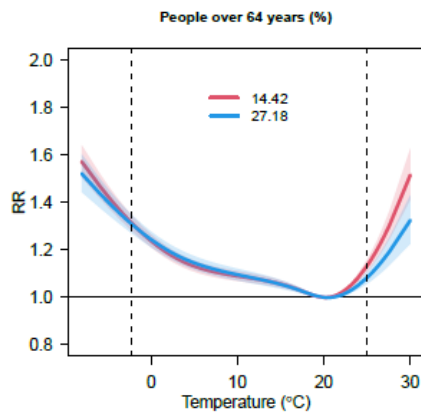
Table S1. Description of contextual indicators

Indicator	Description	Geography	Time	Source
Temperature	Gridded daily mean temperature observations (°C)	0.1deg (≈10km×10km)	2004-2019	E-OBS (Version 30.0e)
Humidity	Gridded daily mean relative humidity observations (%)			
Particulate matter ≤ 10 and ≤ 2.5 µm; nitrogen dioxide; ground-level ozone.	Gridded daily mean estimations (µg/m³)	0.1deg (≈10km×10km)	2004-2019	Chen, ZY. et al. Nat Commun 15, 2094 (2024)
Artificial surface	Proportion (%) of (i) Urban fabric, (ii) Industrial, commercial and transport units, and (iii) Mine, dump and construction sites	Commune (N≈36,000), Arrondissement municipal (N=45)	2006, 2012, 2018	Ministères Territoires Écologie Logement. CORINE Land Cover
Population density	People per km²		2009, 2014, 2020	Observatoire des Territoires Insee. Comparateur de territoires
Rural Population	Proportion (%) of people living in 1km×1km rural grid cells		2015-2019	Insee. La grille communale de densité
Houses built before 1971	Proportion (%) of houses built before 1971		2006-2019	Insee. Recensement de la population
Houses with central heating	Proportion (%) of houses with central heating			
Owned houses	Proportion (%) of houses in property			
Households with 2 or more cars	Proportion (%) of households with 2 or more			
People over 64 years	Proportion (%) of people aged 65 and more		2009, 2014, 2020	Insee. Recensement de la population
People over 64 years living alone	Proportion (%) of people aged 65 and more living alone		2007-2020	Insee. Recensement de la population
People over 24 years without primary education	Proportion (%) of people aged 24 and more without primary school diploma		2009, 2020	Insee. Recensement de la population
Income	Median income by consumption unit (€)		2004-2019	Insee. Dispositif Fichier localisé social et fiscal (Filosofi)
Unemployment	Unemployment rate (%) among people aged 15-64		2009, 2014, 2020	Observatoire des Territoires Insee. Comparateur de territoires
Voting	Proportion (%) of votes for the right		2007, 2012, 2017	J Cagé et T Piketty : Une histoire du conflit politique, Le Seuil, 2023

Figure S1. Predictions of the overall cumulative exposure-response association

The figure represents the relative risk (RR) of mortality associated with daily temperature predicted from univariable meta-regression model for the 10th (red curve) and 90th (blue curve) percentiles of each contextual indicator vs the MMT. Shaded areas represent the 95% CI.





Text S1. Computation of confidence interval for percentage change in risk (%CR) of mortality

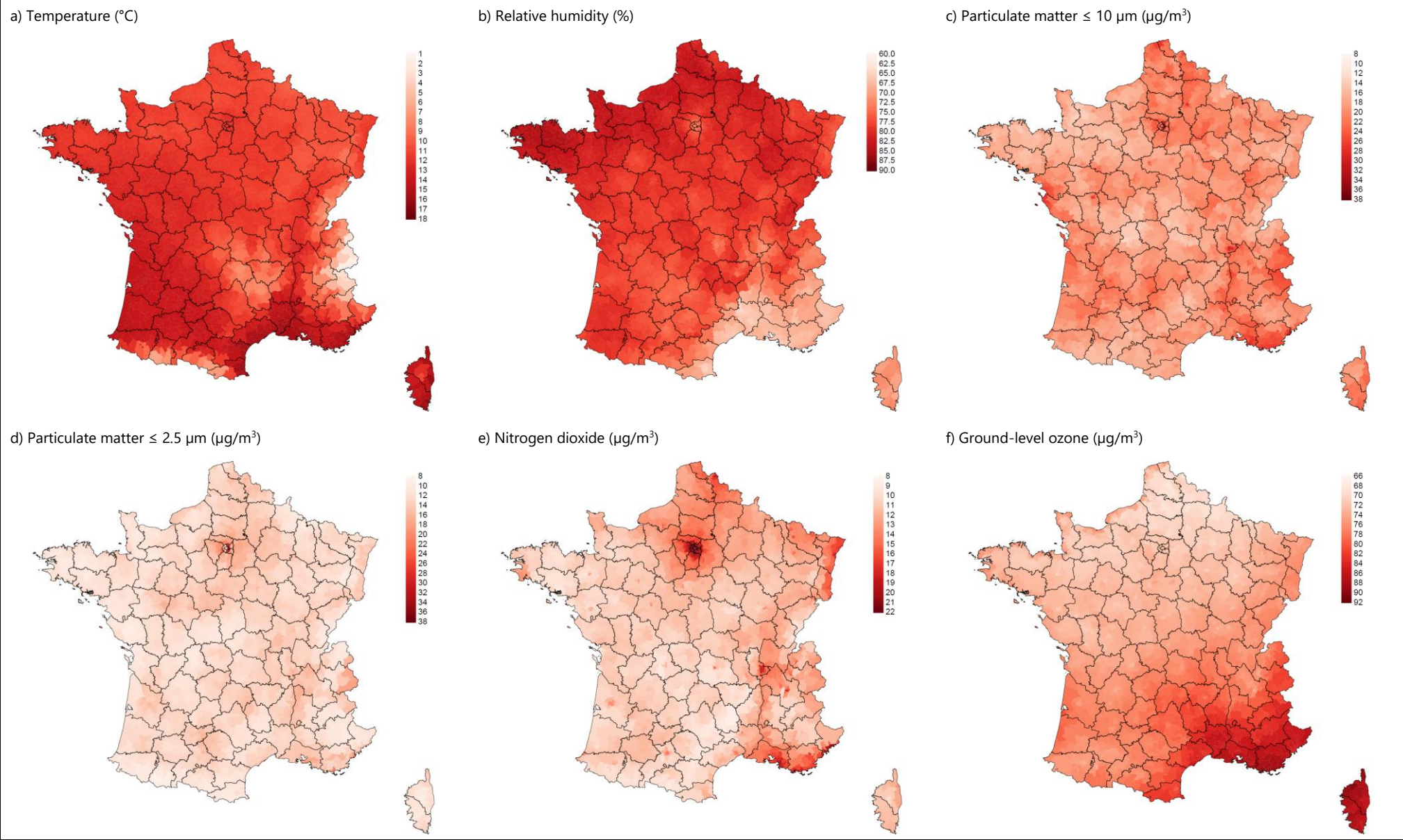
First, we computed the log(RRR) and associated standard error (SE):

- $\log(\text{RRR}) = \log(\text{RR}_{\text{max. value meta-predictor}}) - \log(\text{RR}_{\text{min. value meta-predictor}})$
- $\text{SE} = \text{sqrt}((\text{SE}_{\text{max. value meta-predictor}})^2 + (\text{SE}_{\text{min. value meta-predictor}})^2)$

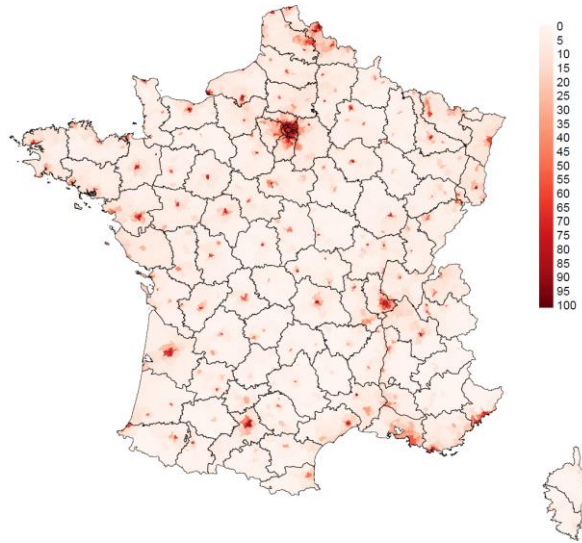
Then, we calculated the confidence interval for %CR as follows:

- Lower bound of CI: $(\exp(\log(\text{RRR}) - 1.96 * \text{SE}) - 1) \times 100$
- Upper bounds of CI: $(\exp(\log(\text{RRR}) + 1.96 * \text{SE}) - 1) \times 100$

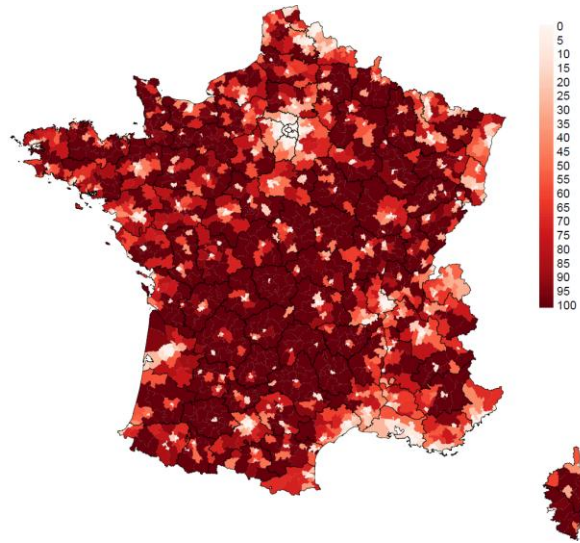
Figure S2. Geographical distribution of contextual indicators



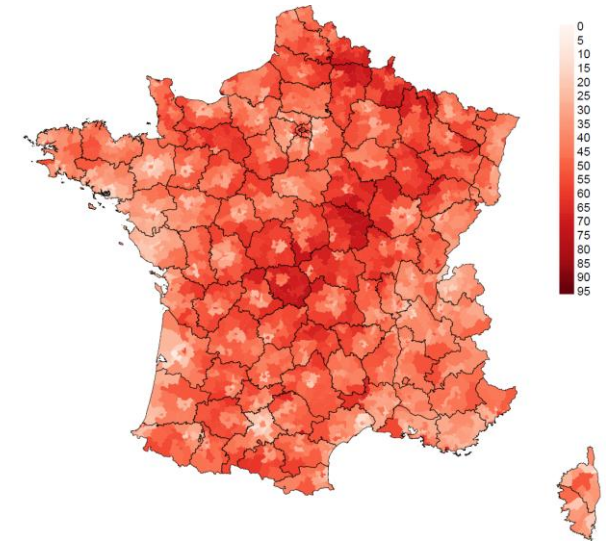
g) Artificial surface (%)



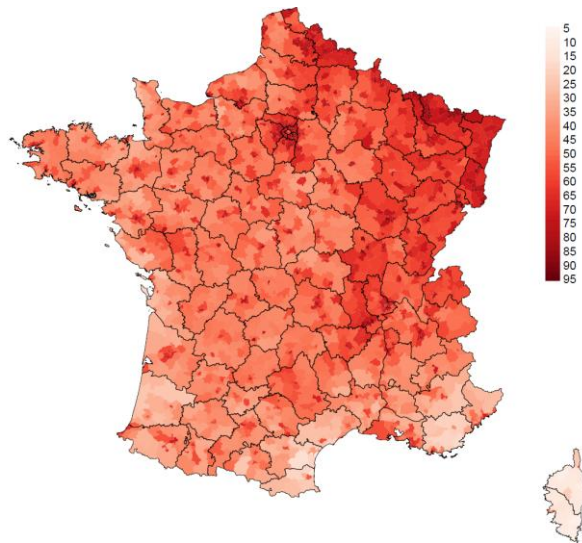
h) Rural population (%)



i) Houses built before 1971 (%)



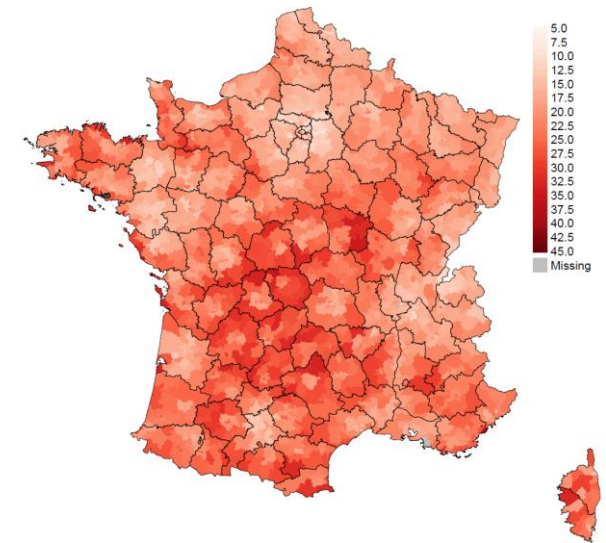
j) Houses with central heating (%)



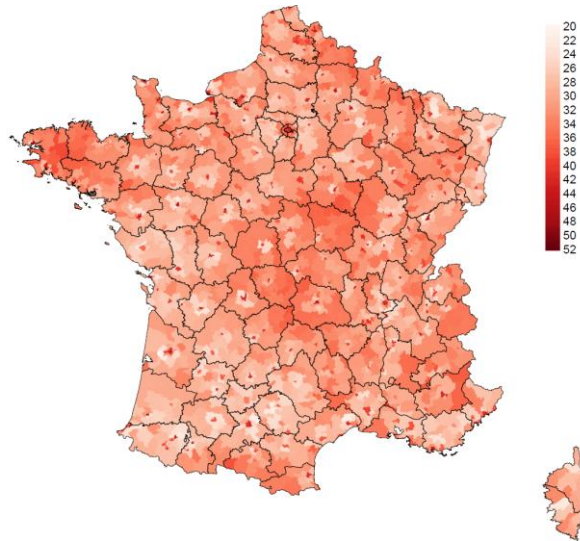
k) Home ownership (%)



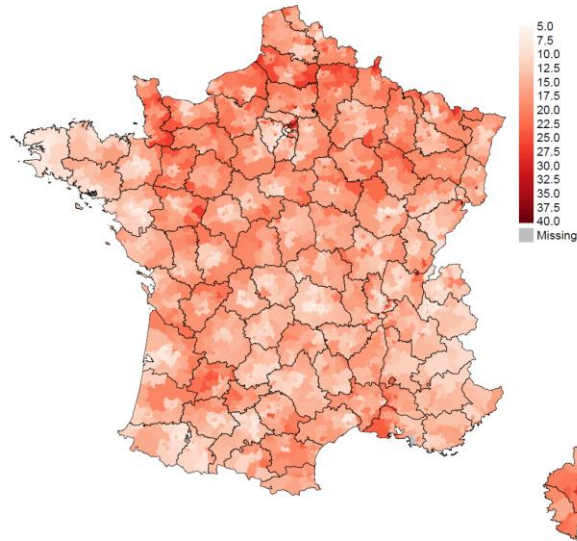
l) People over 64 years (%)



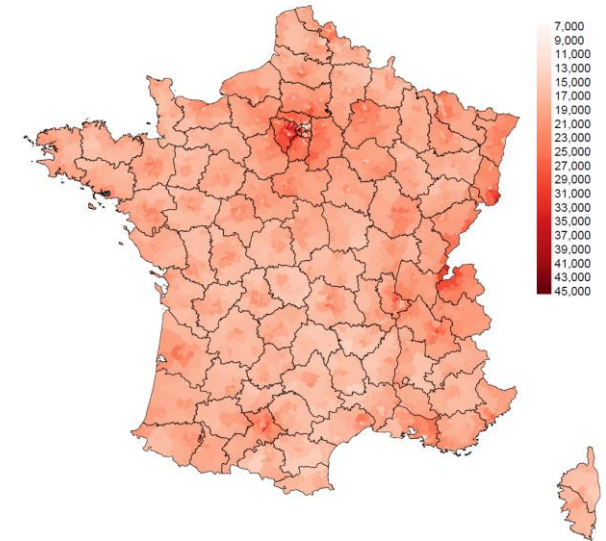
m) People over 64 years living alone (%)



n) People over 24 years without primary education (%)



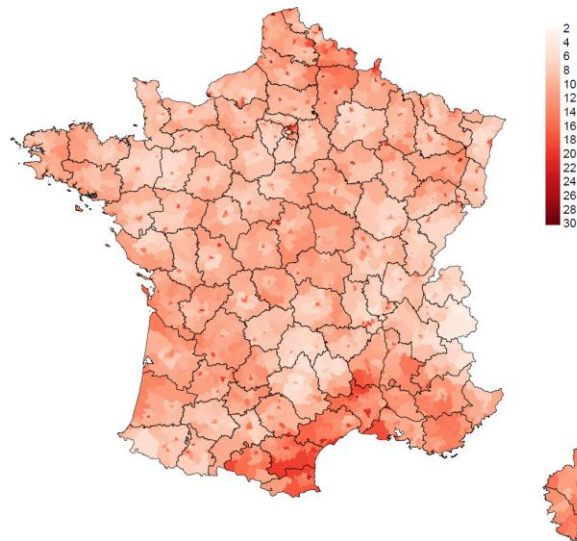
o) Median income by consumption unit (€)



p) Households with 2 or more cars (%)



q) Unemployment rate (%)



r) Votes for the right (%)

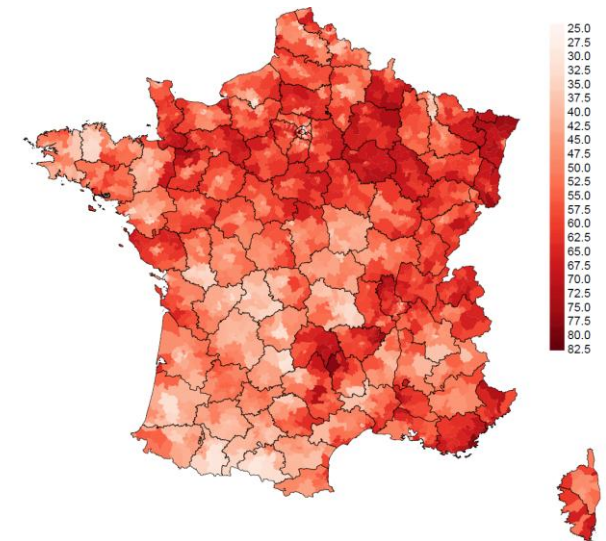


Figure S3. Correlation matrix for contextual indicators

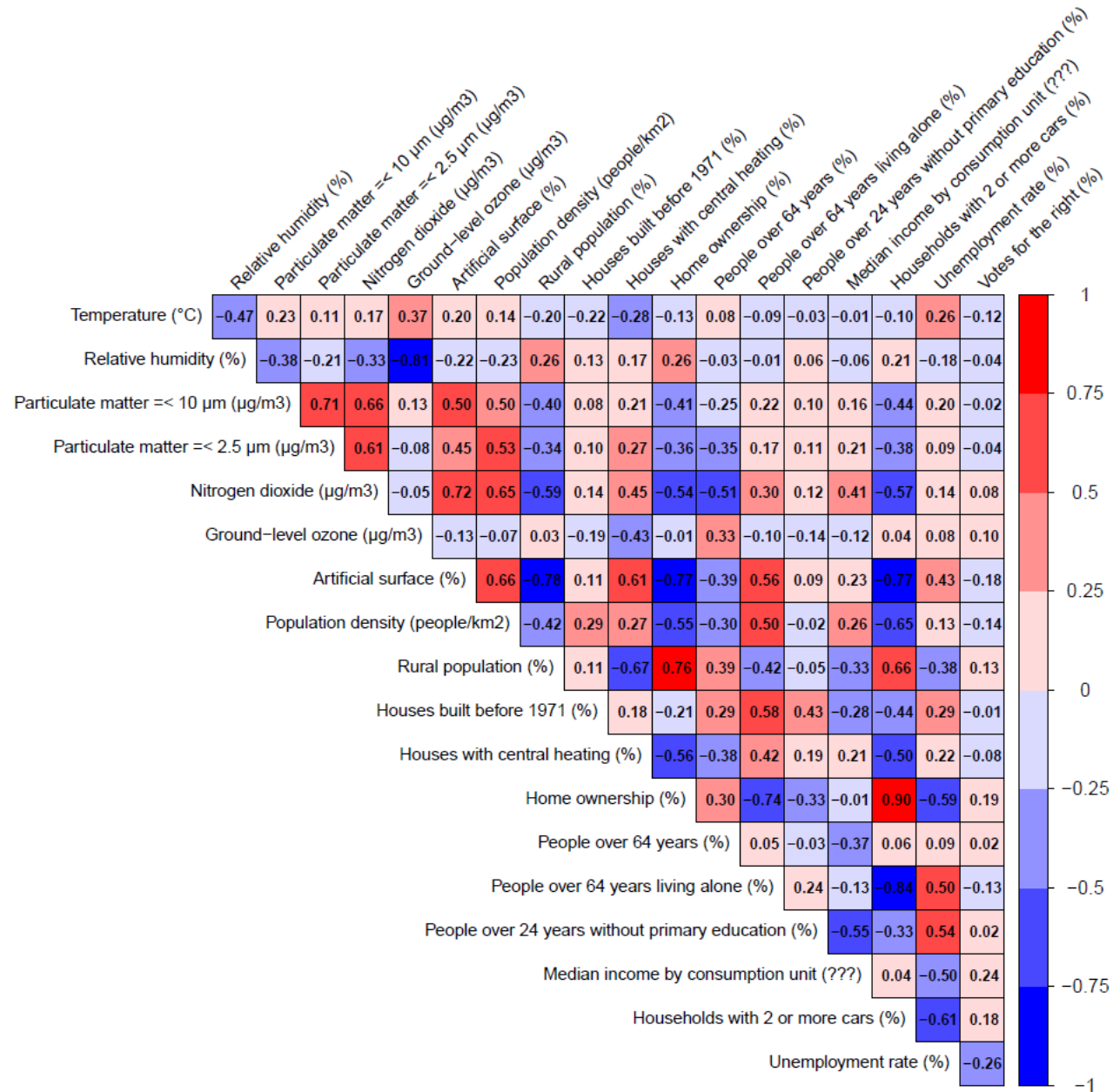


Figure S4. Sensitivity analyses

a) Degrees of freedom for seasonality in the 1st stage time-series regression

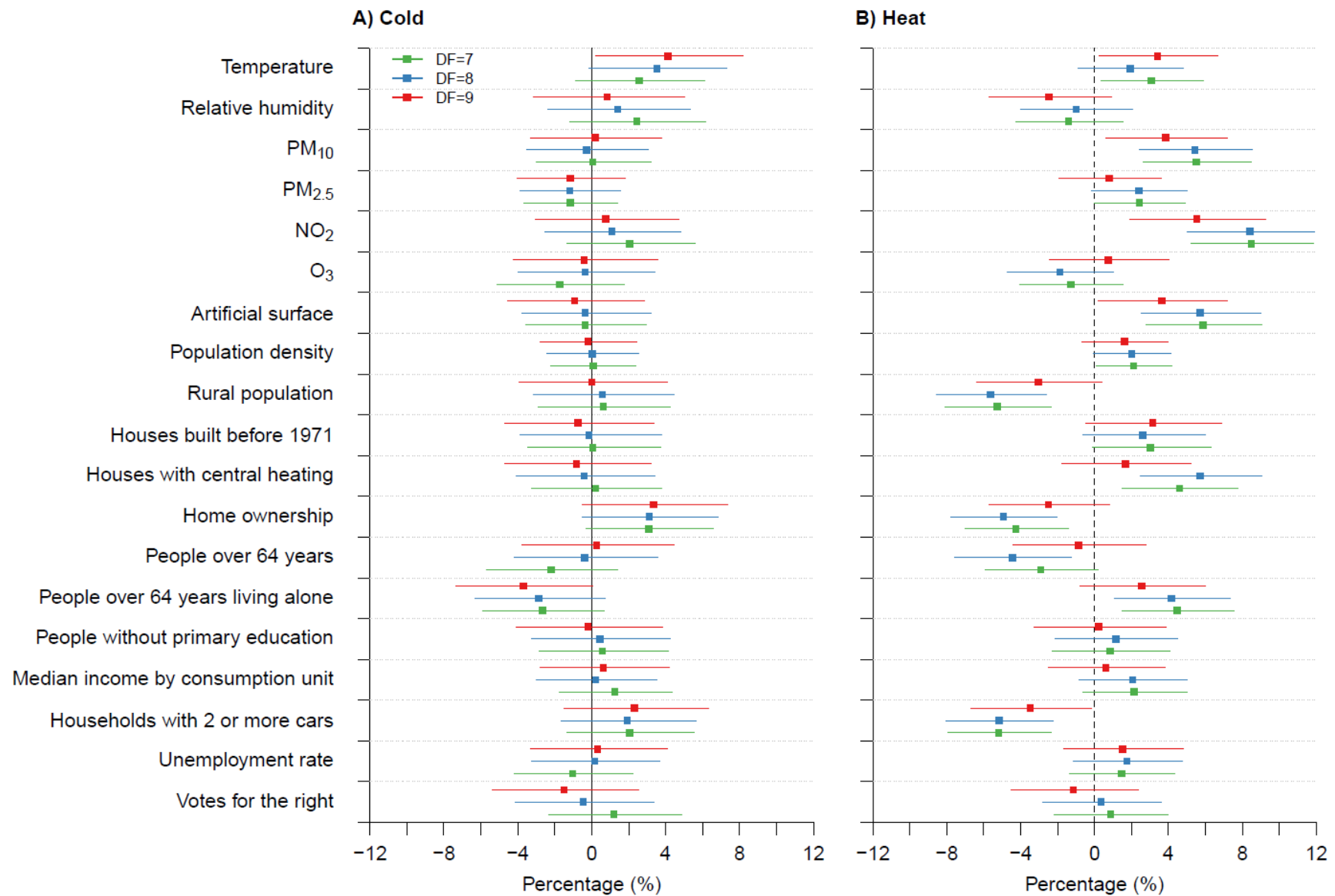


Figure S4. Sensitivity analyses

b) Lag days for the cross-basis of temperature in the 1st stage time-series regression

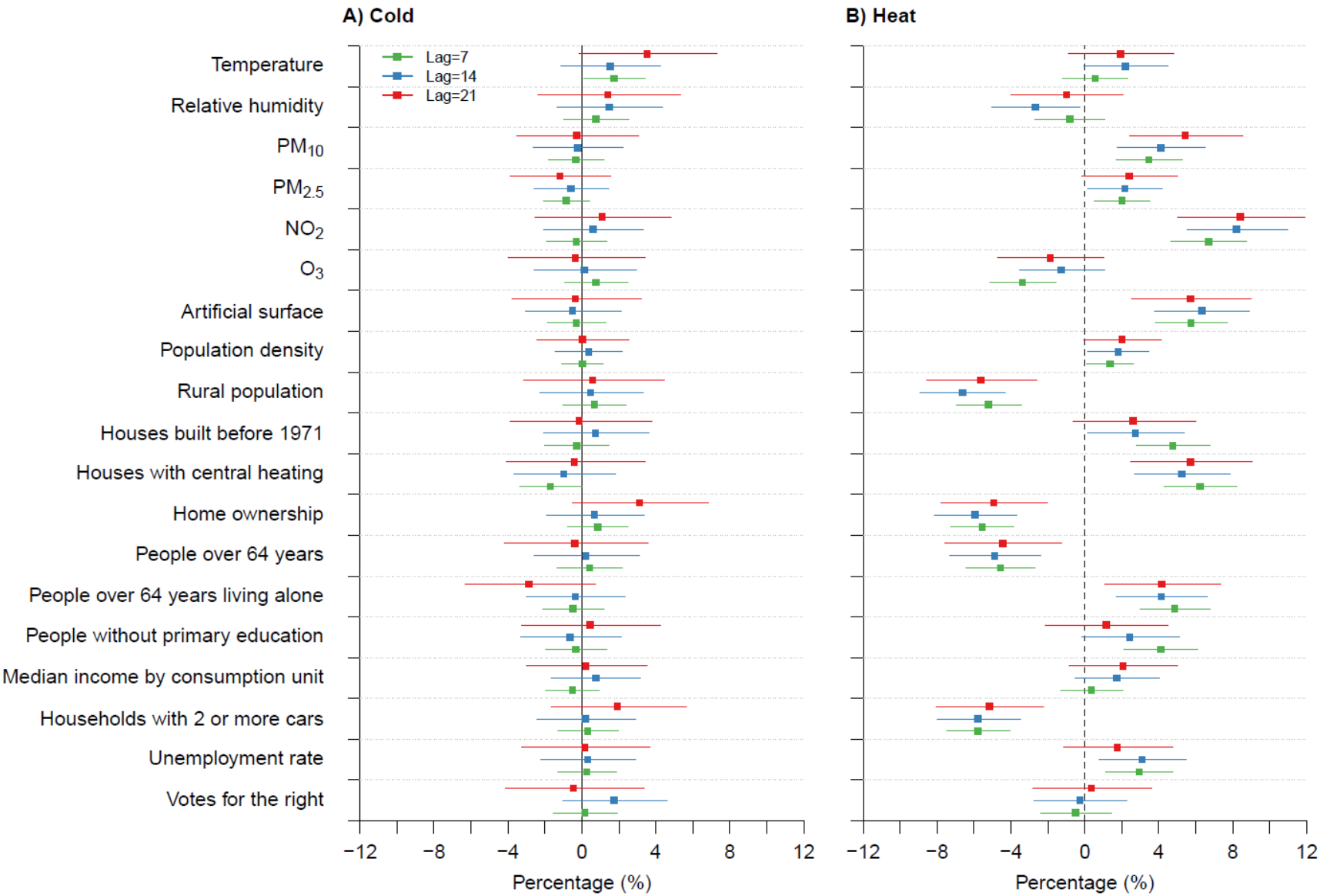


Table S2. Effect modifiers of heat- and cold-related mortality

The table reports the %CR of mortality at the 1st (cold) and 99th (heat) percentiles of daily temperature the 10th and 90th percentiles of each contextual indicator from univariable meta-regression models.

	Cold	Heat
Temperature	3.53 (-0.13 to 7.33)	1.93 (-0.87 to 4.82)
Relative humidity	1.4 (-2.4 to 5.35)	-1.01 (-4 to 2.08)
Particulate matter $\leq 10 \mu\text{m}$	-0.29 (-3.54 to 3.07)	5.42 (2.41 to 8.51)
Particulate matter $\leq 2.5 \mu\text{m}$	-1.19 (-3.88 to 1.57)	2.41 (-0.15 to 5.02)
Nitrogen dioxide	1.1 (-2.52 to 4.85)	8.42 (5.04 to 11.91)
Ground-level ozone	-0.35 (-4 to 3.43)	-1.88 (-4.72 to 1.04)
Artificial surface	-0.35 (-3.79 to 3.22)	5.72 (2.54 to 9)
Population density	0.02 (-2.41 to 2.52)	2 (-0.08 to 4.13)
Rural population	0.58 (-3.16 to 4.46)	-5.64 (-8.57 to -2.62)
Houses built before 1971	-0.14 (-3.9 to 3.76)	2.6 (-0.66 to 5.97)
Houses with central heating	-0.4 (-4.09 to 3.42)	5.72 (2.49 to 9.05)
Home ownership	3.1 (-0.5 to 6.83)	-4.94 (-7.76 to -2.02)
People over 64 years	-0.38 (-4.17 to 3.56)	-4.46 (-7.56 to -1.25)
People over 64 years living alone	-2.86 (-6.3 to 0.71)	4.17 (1.1 to 7.33)
People over 24 years without primary education	0.43 (-3.24 to 4.24)	1.14 (-2.12 to 4.51)
Median income by consumption unit	0.21 (-3 to 3.51)	2.05 (-0.83 to 5.01)
Households with 2 or more cars	1.92 (-1.68 to 5.66)	-5.18 (-8.03 to -2.25)
Unemployment rate	0.16 (-3.25 to 3.69)	1.74 (-1.17 to 4.74)
Votes for the right	-0.45 (-4.16 to 3.39)	0.35 (-2.8 to 3.59)

Table S3. Effect modifiers of heat-related mortality risk after adjustment for nitrogen dioxide

The table reports the %CR of mortality at the 99th percentile of daily temperature between the 10th and 90th percentiles of each contextual indicator after adjustment for nitrogen dioxide.

	Variable	Nitrogen dioxide
Temperature	0.28 (-2.52 to 3.17)	8.33 (4.83 to 11.95)
Relative humidity	2.78 (-0.5 to 6.17)	9.76 (5.99 to 13.67)
Particulate matter $\leq 10 \mu\text{m}$	0.84 (-2.65 to 4.47)	7.71 (3.46 to 12.13)
Particulate matter $\leq 2.5 \mu\text{m}$	-0.76 (-3.44 to 2)	9.15 (5.29 to 13.16)
Ground-level ozone	-3.06 (-5.86 to -0.16)	8.96 (5.47 to 12.57)
Artificial surface	0.79 (-3.02 to 4.74)	7.8 (3.54 to 12.23)
Population density	0.88 (-1.29 to 3.1)	6.39 (2.47 to 10.46)
Houses built before 1971	1.33 (-1.92 to 4.68)	8.2 (4.8 to 11.72)
Houses with central heating	2.94 (-0.37 to 6.36)	7.19 (3.65 to 10.85)
Home ownership	-1.6 (-4.82 to 1.73)	7.49 (3.69 to 11.42)
People over 64 years	-2 (-5.35 to 1.47)	6.57 (2.89 to 10.37)
People over 64 years living alone	1.78 (-1.34 to 4.99)	7.75 (4.2 to 11.42)
People over 24 years without primary education	0.65 (-2.59 to 4)	7.38 (3.86 to 11.01)
Median income by consumption unit	-0.44 (-3.37 to 2.57)	8.68 (5.15 to 12.33)
Households with 2 or more cars	-1.6 (-4.89 to 1.82)	7.45 (3.6 to 11.43)
Unemployment rate	1.14 (-1.76 to 4.12)	8.31 (4.89 to 11.84)
Votes for the right	-1.21 (-4.33 to 2.01)	8.62 (5.18 to 12.17)
Rural population / Nitrogen dioxide	-1.59 (-5.09 to 2.05)	7.4 (3.43 to 11.52)

Figure S5. Relationship between temperature and minimum mortality temperature

The figure represents the relationship between average temperature and minimum mortality temperature (MMT). Bullet points represent spatial units.

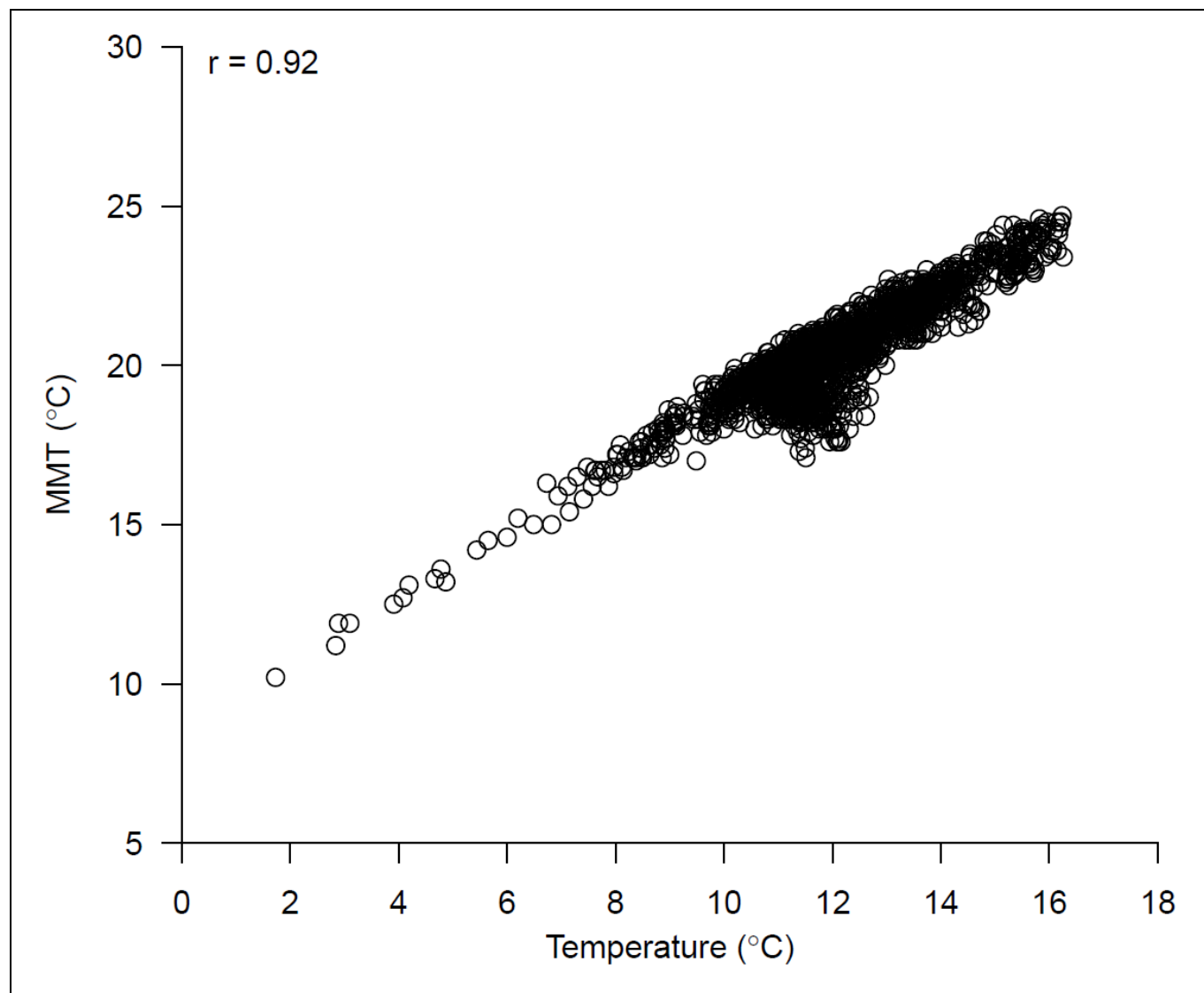
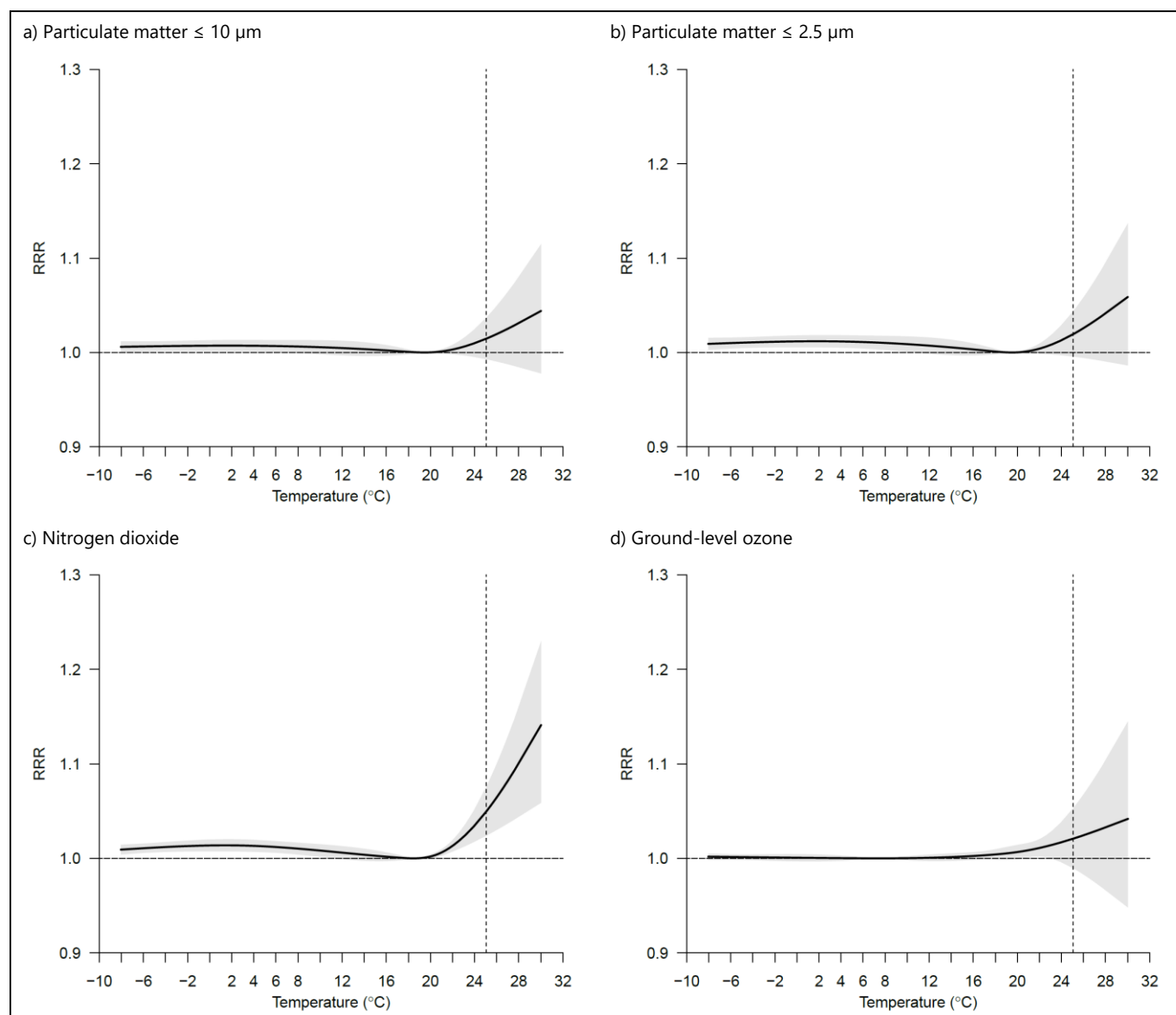


Figure S6. Ratio of temperature-related mortality risk between high and low air pollution days

Ratio of relative risk (RRR) of temperature-related mortality with regard to the minimum mortality temperature (MMT) between high (above canton-specific median) and low (below province-specific percentile) air pollution days. Shaded areas represent the 95% CI.



Description of the statistical analysis:

To assess the effect modification of heat by air pollutants, we included separately in the time-series quasi-Poisson regression model an interaction between the cross-basis function of temperature and dummy variables representing air pollution categories [low (below the pseudo-canton-specific median) and high (above the pseudo-canton-specific median)], and a linear term for the air pollutants in order to account for potential residual confounding.