Trends in heat-related cardiovascular mortality in urban populations of the Czech Republic

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Introduction

The aim of this study is to analyse **temporal changes in hot spell effects on cardiovascular (CVD) mortality** in 3 urban regions of the Czech Republic (Figure 1, Table 1).

Epidemiological data:
We analysed daily mortality due to CVD during 1994–2013 (the Institute of Health Information and Statistics and the Czech Statistical Office) adjusted for different age structure using direct age-standardization according to the European Standard Population (2013 ESP) => **daily number of deaths per million inhabitants**.
Excess mortality => deviations above/below the mortality baseline determined by the location-stratified Generalized Additive Model (‚mgcv' R package) **adjusted** for **trend and season** (a smoothing spline with 7 degrees of freedom/year), and **weekly cycle**.

Meteorological data:
Mean daily temperature (Tavg) for each region in 1994–2013 was calculated by zonal statistics function in QGIS Desktop 2.4.0 from a regular temperature grid (25x25 km) (courtesy of P. Štěpánek, Czech Hydrometeorological Institute).

Hot spells were defined as at least two consecutive days with Tavg above the 90th percentile of temperature distribution in June–August, 1994–2013 (cf. Urban et al. 2016). Mean **excess mortality per million inhabitants during** two weeks after a hot spell onset was examined in order to identify lagged effects of **hot spells**. Statistical significance of mean deviations was evaluated by comparison with the 90% and 95% confidence bounds around the zero line, estimated from the 2.5%, 5%, 95% and 97.5% quantiles of a distribution calculated by the Monte Carlo method.

Trend analyses:
Trends in maximum Tavg and cumulative excess mortality (per million inh.) during hot spells (days 0–4 after a hot spell onset) were examined by bootstrap regression analysis for: (i) all hot spells in June–August 1994–2013, (ii) the first hot spell in a season, in order to adjust the model for influence of within-season acclimatization to heat, and (iii) all hot spells "separated" from a preceding one by at least 3 weeks, in order to take account for a short-term mortality displacement of individual hot spells.

Characteristics of examined regions

Table 1: Characteristics of the districts examined.

Variable	Prague	Brno	Ostrava region
Population (2001)	1 169 106	376 172	596 180
Density (2001)	2377.00	1647.00	1150.50
% unemployed (2001)	2.91	4.71	8.94
Tavg (summers 1994-2013)	18.8	18.9	18.6
90th percentile of Tavg (summers 1994-2013)	23.5	23.4	23.0
Altitude (m a.s.l.)	301.43	328.42	269.23
% of impervious surface (2000)	45.06	33.53	30.83

socioeconomic data: Census 2001, Czech Statistical Office; land cover data: CORINE Land Cover 2000, Czech Environmental Information Agency.

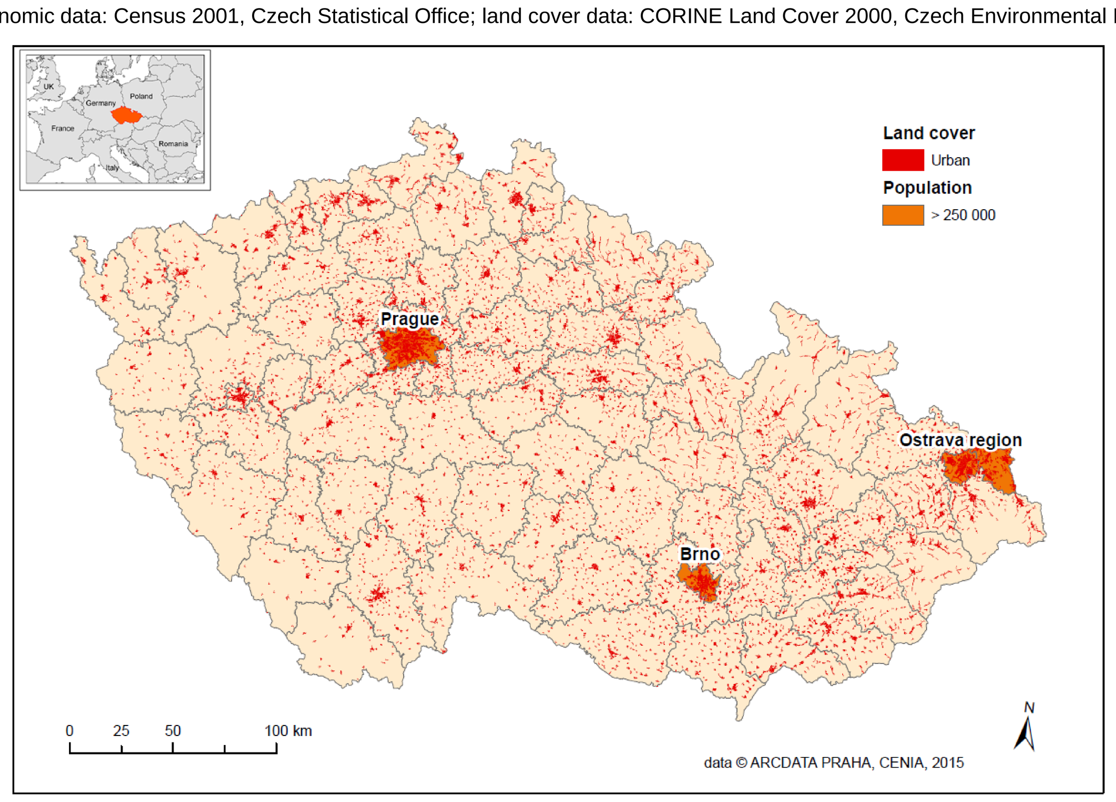

Figure1 Location of examined regions in the Czech Republic.

Frequency and intensity of hot spells

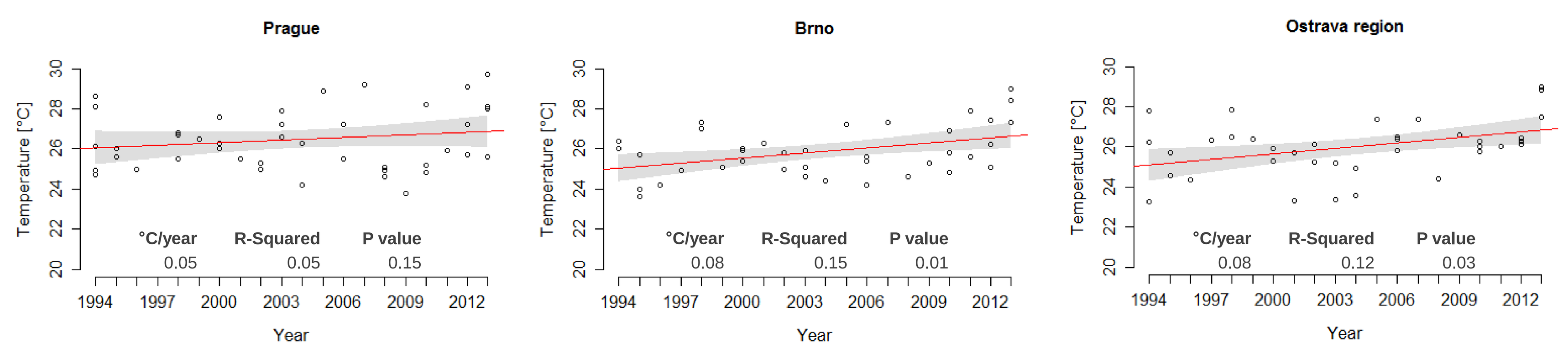

Figure 2: Trends in maximum Tavg during hot spells (days 0–4 of each hot spell) and their characteristics. Shaded areas represent the 95% confidence intervals (CI) of trend estimates.

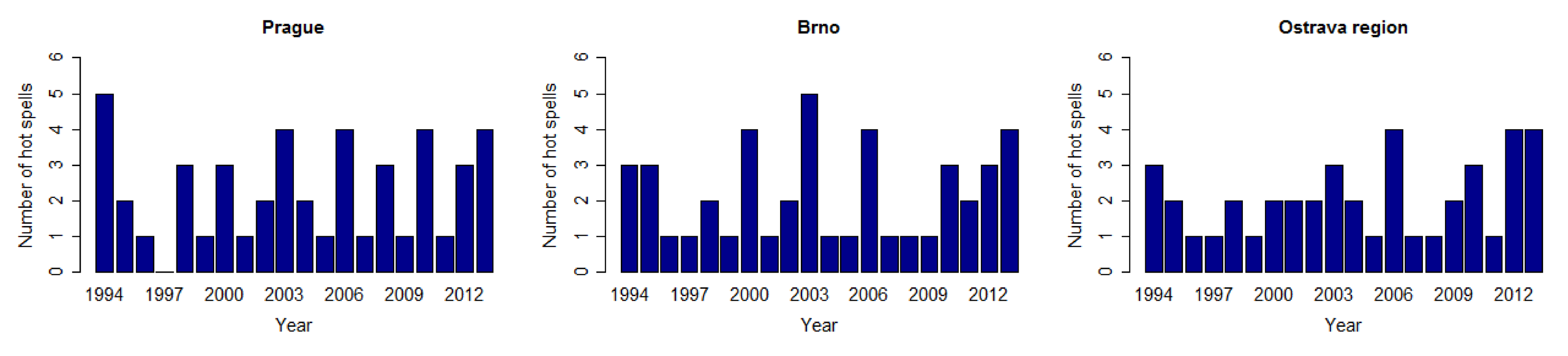

Figure 3: Number of hot spells in June–August,1994–2013.

Effects of hot spells on CVD mortality

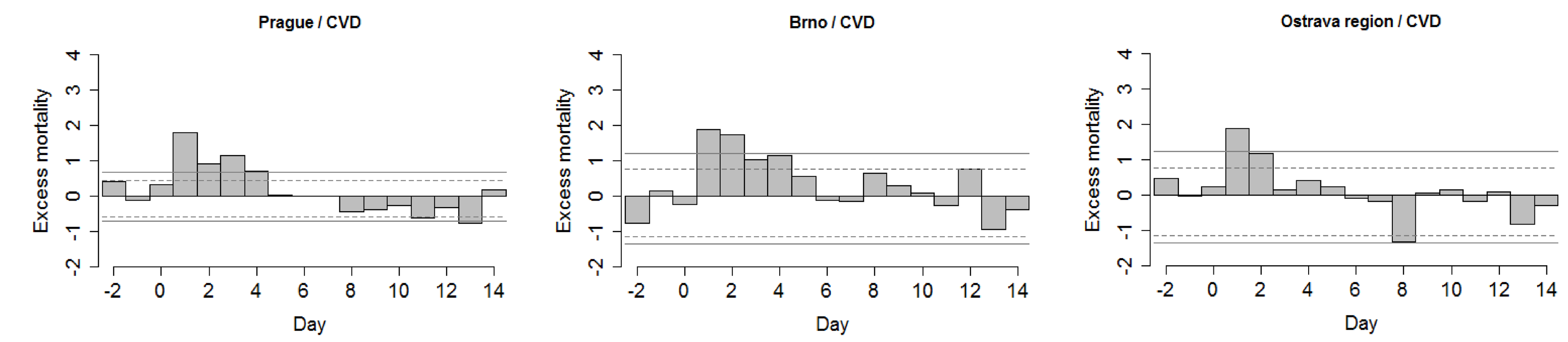

Figure 4: Mean excess CVD mortality (per million inh.) during hot spells. Confidence bounds around zero are indicated by dashed (90%) and solid (95%) lines, respectively.

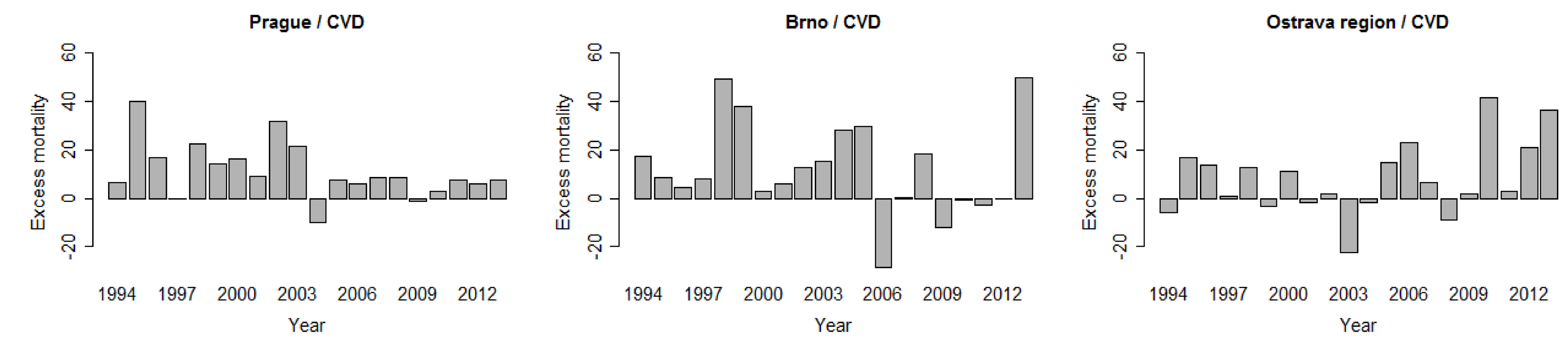

Figure 5: Cumulative effects of all hot spells in a year on excess CVD mortality (per million inh.).

Estimates of annual excess CVD mortality due to hot spells

Table 2: Trends in excess CVD mortality (per million inh.) during hot spells. The 95% CI of trend estimates were calculated by bootstrap regression.

	i) all hot spells			ii) first hot spell in a season			iii) "separated" hot spells		
Region	Deaths/million/ year (95% CI)	R^2	P value	Deaths/million/ year (95% CI)	R^2	P value	Deaths/million/ year (95% CI)	R^2	P value
Prague	-0.39 (-0.77,-0.05)	0.10	0.03	-0.76 (-1.46,-0.25)	0.33	0.01	-0.53 (-0.98,-0.06)	0.16	0.03
Brno	-0.29 (-0.78,0.22)	0.02	0.36	-0.63 (-1.74,0.10)	0.06	0.28	-0.68 (-1.42,-0.09)	0.09	0.11
Ostrava region	0.30 (-0.24,0.70)	0.03	0.22	0.08 (-0.94,0.63)	0.00	0.94	0.11 (-0.56,0.64)	0.00	0.74

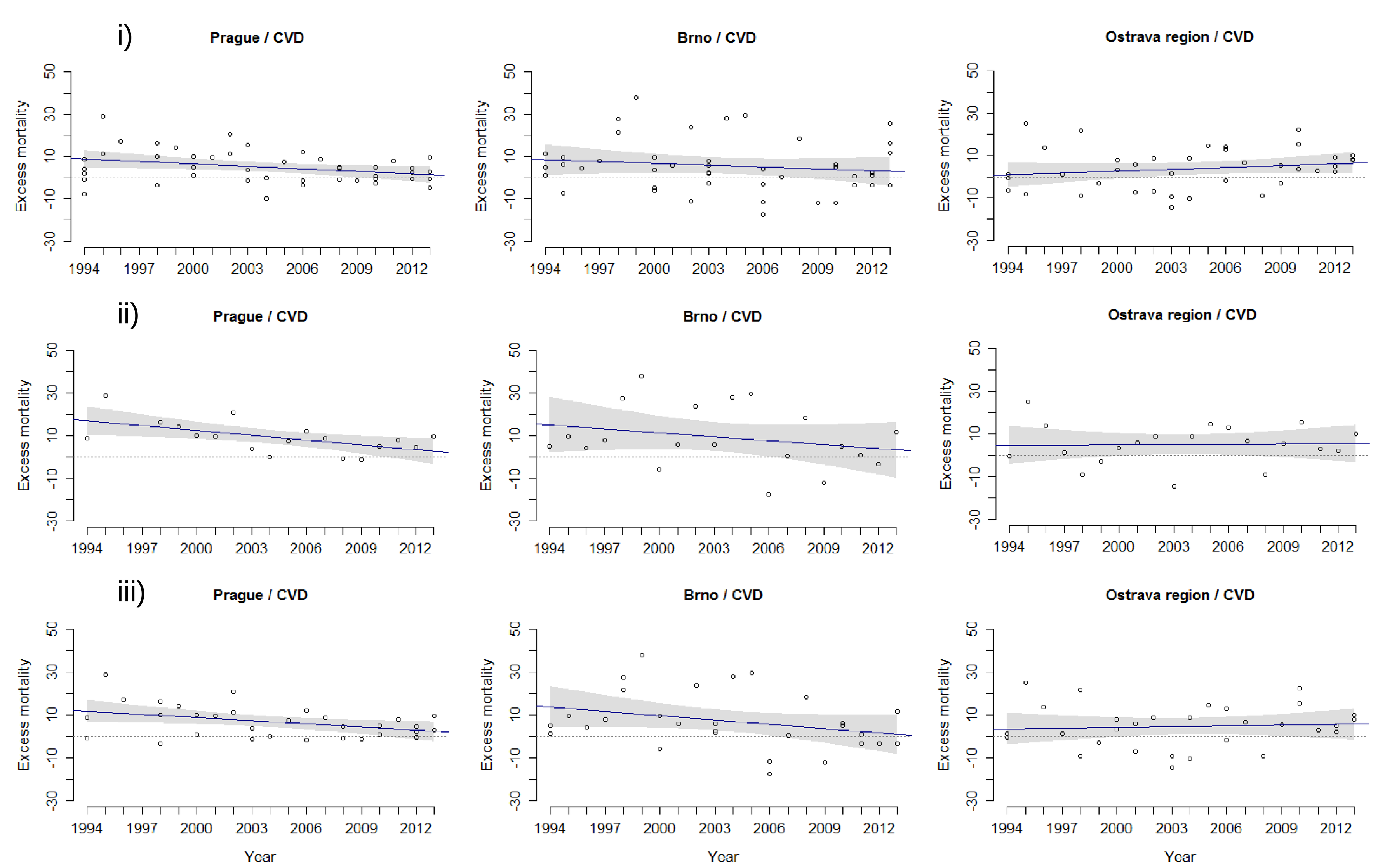

Figure 6: Trend estimates of excess CVD mortality (per million inh.) during (i) all hot spells, (ii) the first hot spell in each season, and (iii) hot spells separated by at least 3 weeks from the previous one (sum of days 0–4) in summers 1994–2013. Shaded areas represent the 95% CI of trend estimates.

Conclusions

- The intensity of hot spells in summer shows a positive trend during 1994–2013 in all regions (Figure 2).
- BUT excess CVD mortality due to hot spells shows a negative trend in Prague (−3.9 deaths/million/10 yrs, p<0.05) and Brno (−2.9 deaths/million/10 yrs, insignificant). On the other hand, there was a positive trend in heat-related CVD mortality in the Ostrava region (+3.0 deaths/million/10 yrs, though insignificant) (Table 2, Figure 6).
- The effects of the increasing hot spell intensity on excess CVD mortality were even weaker (and the positive trend in Ostrava disappeared) if only the first hot spell in each season and "separated" hot spells were considered (Table 2, Figure 6).
- While effects of hot spells on CVD mortality were most pronounced in Prague in the first half of the examined period, population of the Ostrava region was more affected by hot spells in later years (Figure 5).
- However, the largest excess CVD mortality was observed in Brno, if average effects of hot spells were considered (Figure 4).
- **We did not observe any significantly positive trends in heat-related CVD mortality, despite the significant increase in frequency and intensity of hot spells during 1994–2013. The decrease in heat-related mortality was more pronounced in cities with higher socioeconomic status (Prague, Brno) and generally better environment (e.g. relatively lower air pollution concentrations). The contributing factors are currently under study in order to better understand the risks associated with climate change in different populations and regions (cf. Urban et al. 2016).**

References:
Urban, A.; Burkart, K.; Kyselý, J.; Schuster, C.; Plavcová, E.; Hanzlíková, H.; Štěpánek, P.; Lakes, T. Spatial Patterns of Heat-Related Cardiovascular Mortality in the Czech Republic. *Int. J. Environ. Res. Public Health* **2016**, *13*, 284.