Effects of hot and cold spells on cardiovascular mortality in the Czech Republic in individual population groups

J. Kyselý¹, E. Plavcová^{1,2}, <u>H. Davídkovová^{1,3}</u>, J. Kynčl⁴

¹ Institute of Atmospheric Physics, Prague, Czech Republic ² Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic ³ Faculty of Science, Charles University, Prague, Czech Republic

⁴ National Institute of Public Health, Prague, Czech Republic

Contact: kysely@ufa.cas.cz

Aims

The main aims of the study are i) to compare the effects of summer hot spells and winter cold spells on cardiovascular mortality in the population of the Czech Republic, and ii) to compare the mortality impacts in individual population groups (by age and gender).

Data and methods

The dataset (provided by the Institute of Health Information and Statistics) covers all deaths with a cardiovascular disease (CVD) as the primary cause of death in the population of the Czech Republic (~10.2 million) over 1986–2006. Table 1 summarizes mean annual numbers of deaths from CVD in individual population groups and their share in total (all-cause) mortality. CVD were the primary cause in around 55% of all deaths over 1986–2006, and their share in total mortality increases with age.

Standardisation of mortality data

The expected number of deaths $M_0(y,d)$ for year y (y = 1986, ... 2006) and day d (d = 1, ... 365) was set in each population group according to $M_0(y,d) = M_0(d).Y(y)$

$M_{0}(d)$ denotes the mean daily number of deaths on day d in a year, computed from the mean annual cycle smoothed by 15-day running means

Y(y) is a correction factor for the observed year-to-year changes in mortality, defined as the ratio of the



	0–24 yrs	25–59 yrs	60–69 yrs	70–79 yrs	80+ yrs	all ages
M CVD	43.4	4256.7	6462.6	9752.3	8730.9	29246.0
TOT	1451.8	13013.7	13504.0	17340.5	13299.6	58609.5
%	[3.0%]	[32.7%]	[47.9%]	[56.2%]	[65.6%]	[49.9%]
F CVD	30.2	1387.7	3570.2	10460.0	18873.3	34321.4
TOT	763.8	5577.2	7859.1	17250.7	26187.3	57638.1
%	[4.0%]	[24.9%]	[45.4%]	[60.6%]	[72.1%]	[59.5%]

Table 1. Mean annual numbers of deaths due to CVD in individual population groups in the Czech Republic over 1986–2006, and their share in total (all-cause, TOT) mortality in per cent. M = males, F = females.



70-79 vrs







ㅎ 10

โซู -10⊦

[%]²⁵ 20

g -10

ॱᡖ 10⊦

-3

-15

number of deaths in year y to the mean annual number of deaths during the analysed period; Y(y) were calculated over April-November when data are not confounded by epidemics of influenza/acute respiratory infections (ARI)

The excess mortality was established for specific population groups: males (M) and females (F), and for individual age groups as specified in **Table 1** (except for age group 0–24 years in which CVD mortality is very low). Ratios of excess mortality to the expected number of deaths are evaluated, expressed as a percentage above or below the baseline.

Hot (cold) spells are defined as periods of at least 2 consecutive days with anomalies of area-averaged mean daily temperature above the 95% quantile (below the 5% quantile). The quantiles were set from distribution of the anomalies over running 61-day periods centred on a given day of the year. Hot spells are analysed in summer (JJA) and cold spells in winter (DJF). 29 hot spells and 27 cold spells were identified over 1986–2006, with total duration of 83 days (hot spells) and 90 days (cold spells). Interannual variability of hot and cold spells as well as mean seasonal temperatures are depicted in Fig. 2.

Methods

Relative deviations of mortality from the baseline on days D-3 (3 days before the beginning of a hot/cold spell) up to D+16 (16 days after) were averaged over the identified hot/cold spells. Statistical significance of this mean relative deviation of mortality was evaluated by comparison with the 90% and 95% confidence interval (CI) around the zero line, estimated from the 2.5%, 5%, 95% and 97.5% quantiles of a distribution calculated by the Monte Carlo method. Periods in which mortality was affected by influenza/ARI epidemics were excluded from all calculations.

Results

Both hot and cold spells are linked to significant excess CVD mortality (Fig. 4), but there is a conspicuous difference in the lag: while the effects of hot spells are direct and occur on days of hot spells (significant excess mortality on days D+0 to D+3 in the whole population and M, and on days D+0 to D+4 in F), the effects of cold spells are substantially more lagged (excess mortality lies outside the 90% CI on days D+1 to D+13 in the whole population, and on most days between D+2 and D+13 also outside the 95% CI).

Pronounced differences in the impacts of hot spells are found between M and F: excess mortality is much larger in F, exceeding +20% on day D+2, while it is approximately half that level in M (Fig. 4). The effects of cold spells are comparable in M and F as to the magnitude, but the lag tends to be slightly shorter in M than F (excess mortality lies outside the 90% CI already on days D+1 and D+2 in M while from day D+3 in F; **Fig. 4**).



Fig. 2. Seasonal counts and durations of hot spells (left) and cold spells (right), and mean seasonal temperatures over 1986–2006. Winter is defined by the year it ends (e.g. winter 1986/1987 is labelled as 1987).





Fig. 3. Mean daily temperature anomalies on days D-3 to D+16, averaged over hot spells (left) and cold spells (right). The upper and lower bounds show +/- one standard deviation around the mean

Fig. 5 compares the effects of short hot/cold spells (2–3 days) with longer spells (4+ days).

Fig. 6 shows that the effects of hot spells on CVD mortality increase with age. They are particularly pronounced in the oldest age group (80+ years), in which significant excess mortality occurs on all days D+0 to D+4.

For cold spells in winter, the figure looks completely different than that for hot spells in summer. Rather surprisingly, the relative excess mortality is most pronounced in the middle-aged population (25–59 years), in which the largest excess mortality is unlagged (days D+0 and D+1). Significant excess mortality is more lagged in the older age groups. This feature is particularly well-expressed in the oldest age group (80+ years), for which significant excess mortality is found for lags D+6 to D+11 and not for lags which correspond to direct cold-stress effects.

The impacts in individual population groups are further differentiated by splitting the age groups by gender (Figs. 7 and 8). Fig. 7 reveals that for hot spells, the larger magnitude of the mortality impacts in the elderly is predominantly due to increasing vulnerability of females with age while the impacts in males depend relatively little on age. For cold spells (Fig. 8), it is found that the pronounced unlagged mortality effects in middle-aged population are related to males only.





Fig. 4. Mean relative deviations of mortality for 20-day sequences D-3 to D+16 for hot spells (left) and cold spells (right) for the whole population (M+F, top), males (M, middle) and females (F, bottom). Days are counted from the beginning of a hot/cold spell. Solid (dashed) lines denote the 2.5% and 97.5% (5% and 95%) guantiles of deviations obtained by the Monte Carlo method.



More detail in

Kyselý J, Plavcová E, Davídkovová H, Kynčl J (2011) Comparison of hot and cold spell effects on cardiovascular mortality in individual population groups in the Czech Republic. Clim Res 49:113-129 doi 10.3354/cr01014.



Fig. 6. Same as in Fig. 4 but for different age groups.

Fig. 7. Same as in Fig. 4 but for hot spells and different population groups. Vertical axes have been rescaled so that the width of the confidence intervals around zero is similar in all plots.

Fig. 8. Same as in Fig. 7 but for cold spells.

Conclusions Differences between mortality impacts of hot and cold spells

• Both hot and cold spells are associated with significant excess cardiovascular mortality.

• The effects of hot spells are more direct (unlagged) and typically concentrated on a few days of a hot spell (significant excess mortality on days D+0 to D+4 from the beginning of a spell).

- Cold spells are associated with indirect (lagged) mortality impacts that persist after the end of a cold spell (significant excess mortality on days from D+1 to D+13).
- Although the mortality peak is less pronounced for cold spells, the cumulative magnitude of excess mortality is larger for cold than hot spells.

Differences between mortality impacts in population groups

• Gender differences consist mainly in much larger excess mortality of females in hot spells and more lagged effects in females than males associated with cold spells.

• Effects of hot spells have a similar temporal pattern in all age groups but much larger magnitude in the elderly. For cold spells, by contrast, relative excess mortality is largest in the middle-aged population (25-59 years).