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Analysis of links among epidemiological situation and stressing weather and air pollution stressing factors

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Introduction	3
Study period and data used.....	3
Qualitative data analysis.....	5
Quantitative data analysis.....	6
Further work.....	9
References	9

Introduction

Air quality is fundamentally governed by weather conditions which determine the transport and dispersion conditions of pollutants and their precursors on the one hand and their emission rates on the other hand, including biogenic emissions. Situations with a poor air quality, manifested primarily by increased concentrations of particulate matter and ozone, are documented to cause worsening of epidemiological situation, particularly among sensitive groups of population. Thus, application of effective measures aimed at decreasing of air pollution level during such episodes is requested.

The health impacts, however, are also caused by or correlated with some meteorological factors such as very low or very high temperature or sultriness. This complicates the detection of primary cause of health problem outbreaks (air quality and/or stressing weather factors) and might induce the ineffectiveness of measures applied. Moreover, the effects are also masked by chaotic short-term fluctuations mortality-displacement (“harvesting) effect. Results of health data and weather variables relationship analysis are summarised in this report.

Study period and data used

Years 2003 and 2004 were analysed during the study provided within the GEMS project. The study period has been extended by four years and encompasses 6 years from 2003 till 2008 now.

Combined effect of air temperature, humidity and wind speed on the human well-being and health is widely reported in the literature. Various types of weather indices are usually constructed using these meteorological variables as an input (e.g Leung et al., 2008). For the purposes of this study, meteorological data on ambient air temperature, relative humidity and wind speed from man-serviced and automated station network operated by Czech Hydrometeorological Institute (CHMI), were utilized. This network covers the whole territory of the Czech Republic. With the aim to exclude the influence of extreme conditions, stations situated at height below 700 m a.s.l. were incorporated.

Detailed information on the Czech station network, including maps, might be found on the CHMI website <http://www.chmi.cz>.

Health data, comprising daily hospital admissions and daily death counts for 2003 – 2008 period, split by patient’s domicile (region) and selected diagnoses (cardiovascular, cerebrovascular and respiratory diseases, according to International Statistical Classification of Diseases and Related Health Problems), were kindly provided by the Institute of Health Informatics and Statistics of the Czech Republic.

Study area and its administrative partitioning (regions and districts) are depicted on the map in Fig.1.



Fig. 1: Czech Republic (the study area) and its administrative partitioning

The web sites of the Czech Statistical Office, <http://www.czso.cz/eng/redakce.nsf/i/home>, provide comprehensive geographical and demographical information.

Example of health data tables (daily mortality data) provided by Institute of Health Informatics and Statistics, split according to ICD-10, is shown on the Fig.2.

Datum	G40	I20 - I25	I60 - I69	J00 - J06	J10 - J18	J20 - J22	J44	J45
1.1.2004		4			2		1	
2.1.2004		2	4					
3.1.2004		3	3					
4.1.2004		2	3		2			
5.1.2004			3					
6.1.2004		2	2					
7.1.2004		3	1		2			
8.1.2004		4			3		2	
9.1.2004		2	2		3			
10.1.2004		1	2		1			
11.1.2004		1	4		1			
12.1.2004		2	3		2		2	
13.1.2004		1	1	1				
14.1.2004		1	3		2		1	
15.1.2004		1	4		1			
16.1.2004		1	3		2			
17.1.2004		4						
18.1.2004			1		1		1	1
19.1.2004		1	3		3		1	
20.1.2004		2	1		2			
21.1.2004		5	2					
22.1.2004		2	2				1	
23.1.2004		3			3			
24.1.2004		4	2				1	
25.1.2004			2				1	
26.1.2004		1	1		3	1		
27.1.2004		6	2		2			
28.1.2004		3	3		1		1	
29.1.2004		4	1					
30.1.2004		6	5				1	

Fig.2: An example of health data tables provided by IHIS.

Qualitative data analysis

In the first step, mortality data time changes and their correlation with temperature were analysed.

An example of time course of the total daily mortality in period 2004 – 2008 (summarised for cardiovascular, cerebrovascular and respiratory diagnoses over the whole CZ territory) is shown on Fig.3.

A yearly course with explicit maxima in winter month and marked mortality minimum in summer is highlighted by the overlaid trend curve where short-term fluctuations were filtered by LOESS (locally weighted scatterplot smoothing). Similar graph was constructed for a time course of cardiovascular diseases caused deaths (Fig. 4).

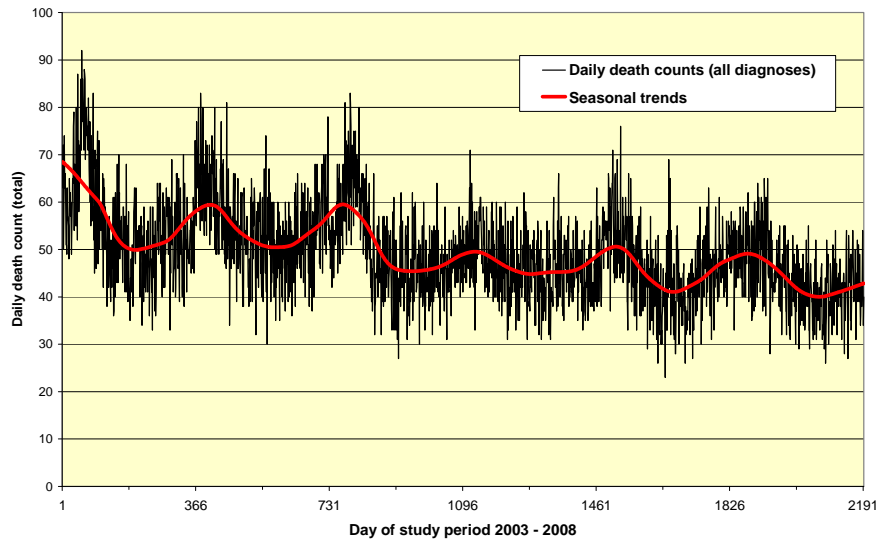


Fig.3: Time course of total daily mortality summarised for cardiovascular, cerebrovascular and respiratory diagnoses in Czech Republic in period 2003 -2008

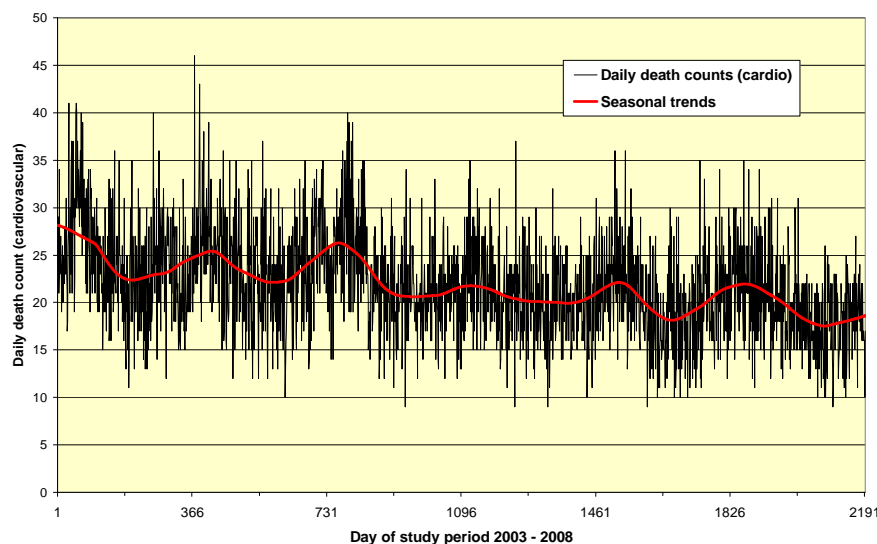


Fig.4: Time course of cardiovascular daily mortality in Czech Republic in period 2003 -2008

With the aim to obtain some idea on relation and correlation between mortality and ambient air temperature, curves of both values were compared in the manner as shown on example in Fig. 5, where the collocated time courses daily mean temperatures averaged over the Czech Republic territory are and daily counts of cardiovascular mortality for 2005 are presented.

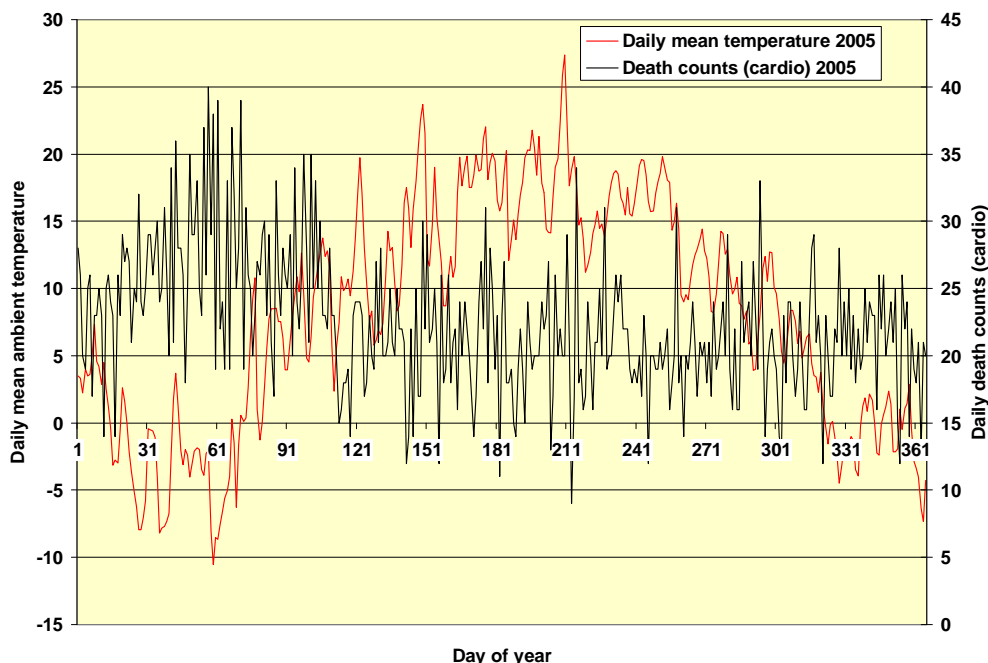


Fig.5: Time changes of total daily cardiovascular mortality in Czech Republic in 2005 collocated with daily mean temperature (averaged over the CZ territory)

Particularly interesting peculiarities were found on such graphs:

- Some mortality peaks are well correlated with the temperature peaks in warm season of year (well known as “heat waves”).
- Sudden temperature jumps from minus to plus temperatures observed in winter seem to cause mortality increase, especially due to heart problems

Similar analysis as for the total mortality has been provided for all another diagnoses and it became evident that meteorological factors must also be taken into account making analysis of pollutants concentrations effect on human health in Czech Republic.

Quantitative data analysis

With the aim to derive some quantitative relations between meteorological variables and mortality rates, following steps were applied:

- The combined effect of air temperature, humidity and wind speed has been involved using so called apparent temperature according Steadman (1994).
- According to Stedman’s formulas, mean daily values of apparent temperature (AT) were calculated for each day of the study period and each meteorological station used. Wind speed has been fixed to 3m/s, a long term mean for the Czech Republic. From the station data the territorially averaged values may be determined.

- Following the concepts described in Schwartz (2000), the time series of mortality counts were decomposed into 3 components: long-term (reflecting the seasonal effects), mid-term and short-term (chaotic) part.
- The LOESS smoothing method described by Schwartz (2000) has been selected as the most appropriate for this purpose.
- Following this approach, the mid-term parts of daily death counts time series were extracted with time changes having periods shorter than 120 days and longer than 15 days. The confounding components with longer and shorter periods were removed, specially the so called “harvesting effect” (Schwartz, 2000).

In the further analysis these slowly changing smooth component bearing the substitution information were treated together with the apparent temperature values.

On figure 6 a scatterplot of the mid-term daily total mortality counts plotted versus apparent temperature (AT) is depicted. Application of LOESS smoothing with the span 40% of the data range has been applied to make the relationship distinctive. The validity of relationship between mortality and AT in form of V-like curve reported in many literature references (e.g. Huynen et al., 2001) has been proven for the Czech Republic as well.

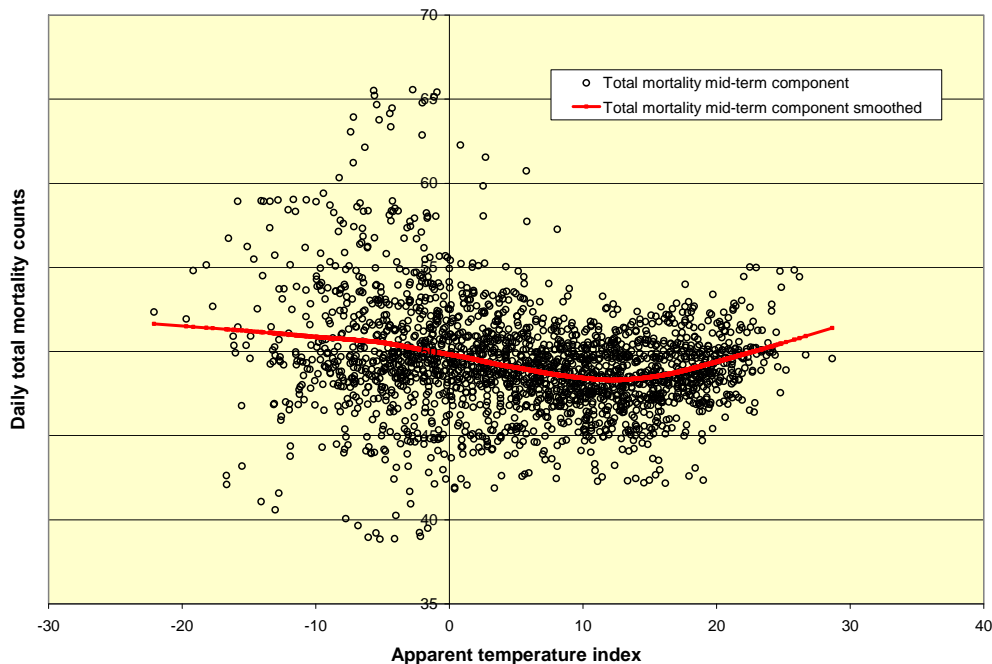


Fig.6: Scatterplot of the mid-term daily total mortality counts versus (AT). The LOESS smoothed curve shows the V-like form of the relationship.

Applying the same procedure, the relationships between AT and mortality counts for other particular diagnoses (cardiovascular, cerebrovascular and respiratory) were provided. The results are shown on figure 7.

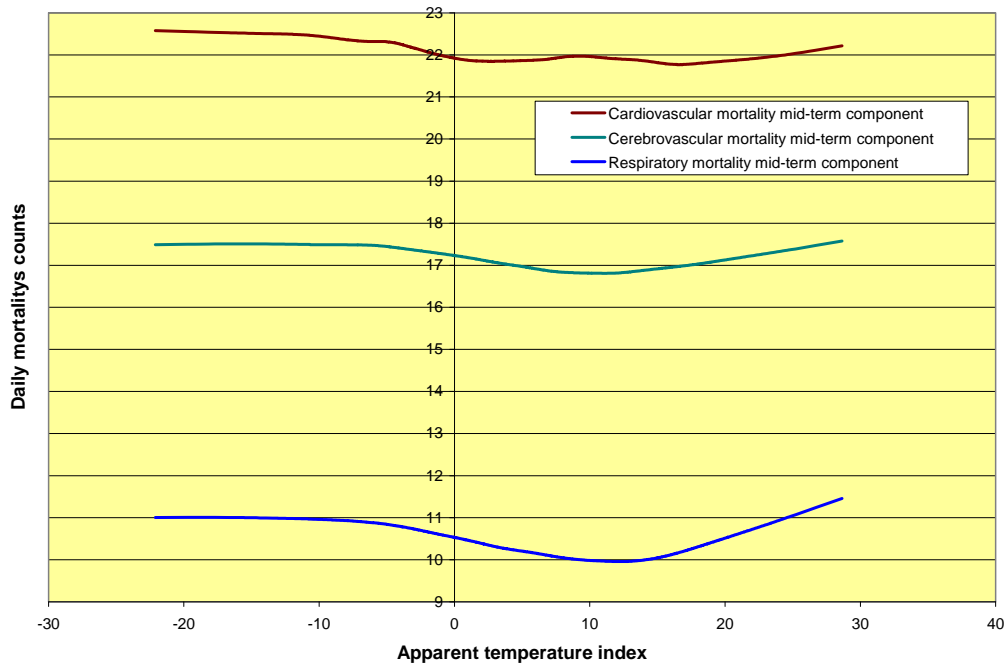


Fig.7: The LOESS smoothed curves of the mid-term daily mortality counts for cardio-, cerebrovascular and respiratory diagnoses versus AT

The V-like relationships shows that there exists some “optimal value” of apparent temperature for which the daily mortality count reaches its minimum for particular diagnose. The values of optimum AT are summarized in the following table.

Diagnose	Total	Cardiovascular	Cerebrovascular	Respiratory
Mininum daily mortality count	48	22	17	10
Optimal AT	12.1	16.8	11.1	12.4

The mortality counts increase with decreasing of AT below the optimal value and increasing of AT above it as well. In the range of negative AT values a saturation level is reached for each diagnose and mortality counts remain constant.

Coefficients of the Poisson regression model in form

$$\ln(\mu) = A + B*AT$$

with total mortality daily count as dependent variable were estimated for AT values above the optimum level *12.1*. The value $B = 0.00386$ indicates that for AT above the optimum threshold an increasing of AT by 1 causes an increase of total mortality by 1 ($\exp(0.00386) = 1.0034$). Thus, an influence of apparent temperature on death counts looks to be not negligible and AT (or another weather index) must by included into analysis of aggregated impact of selected meteorological variables and air pollution concentrations.

Further work

Attempts to test if the data available enables to expand the analysis into more detail, from the whole CZ territory to the particular regions, are in progress. The quantitative relationships between pollutants concentration an increase of mortality will be evaluated using Poisson regression, with meteorological variables incorporated.

This enables, with the concentration data provided by combination of monitoring data and models prediction, to forecast an increasing of risk caused by air pollution burden.

References

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