The current issue and full text archive of this journal is available at
www.emeraldinsight.com/0965-3562.htm

RESEARCH PAPER

Does Belgrade (Serbia) need heat health warning system?

Gorica B. Stanojević
Physical Geography Department, Geographical Institute "Jovan Cvijic" SASA, Belgrade, Serbia
Aleksandra B. Spalević
Spatial Planning Department, Geographical Institute "Jovan Cvijic" SASA, Belgrade, Serbia, and
Vlasta M. Kokotović and Jelena N. Stojilković
Social Geography Department, Geographical Institute "Jovan Cvijic" SASA, Belgrade, Serbia

Abstract

Purpose – The purpose of this paper is to investigate whether is Belgrade (Serbia) suitable candidate for introduction of Heat Health Warning System (HHWS). Belgrade has high population density, considerable share of built up area and lot of multi floor buildings that are factors of heat-health vulnerability.

Design/methodology/approach – The authors analyzed the impact of weather conditions on human health in Belgrade during the summer 2007 that was extremely warm in Southeastern Europe and Serbia. Daily cardiovascular, cerebrovascular and respiratory mortality counts were used in Poisson regression model with air temperature as predictor variable. Also, three different heat wave indices (Warm Spell Duration Index, apparent temperature and index based on daily minimum temperature) were tested in order to estimate their ability to capture episodes with mortality higher than expected.

Findings – The temperature has the highest influence on cerebrovascular and cardiovascular mortality, while slightly modifies respiratory mortality. According to regression equation, a 1°C increase in mean daily temperature is associated with a 4.6 percent ($p<0.0001$), 2.2 percent ($p<0.0001$) and 1.6 percent (insignificant for $p<0.10$) increase in cerebrovascular, cardiovascular and respiratory mortality, respectively.

Originality/value – Even thought the Law recognizes the heat wave as natural hazard, there is no concrete measures and action for prevention of excess mortality. It is shown that extreme temperature had numerous social consequences on city's residents in the summer 2007. Given the results the authors got, it is recommended that the HHWS should be implemented in health protection plans in Belgrade.

Keywords Climate change, Natural hazard, Mortality, Poisson regression, Heat wave, Heat Health Warning System, Belgrade, Summer 2007, Daily mortality

Paper type Research paper

Introduction

According to predictions of global and regional climate models, the frequency, duration and intensity of heat waves may increase in the future in many regions of the world (Meehl and Tebaldi, 2004). Extreme events such as 1995 Chicago heat wave or 2003

This study is supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia – Project III47007.

Disaster Prevention and Management
Vol. 23 No. 5, 2014
pp. 494-507

0965-3562
DOI 10.1108/DPM-11-2013-0200

European heat waves led to increased interest in the impact of weather conditions on human health (Semenza *et al.*, 1996; Anderson and Bell, 2009; Medina-Ramón *et al.*, 2006). In the last decades, Southeastern Europe and Balkan region are affected with extreme temperature events, but the absence of data is the main reason for no mitigation procedure on heat wave consequences (Robine *et al.*, 2008).

Extremely high temperatures have negative impact on human health, in some cases with fatal outcomes. Mostly, the studies have investigated the heat wave impacts on different groups of vulnerable population. The high risk groups include elderly – those older than 65 years (Fouillet *et al.*, 2006; Kovats and Ebi, 2006), socially isolated, people who are living alone and people with low income (Naughton *et al.* (2002)), etc. Also, there is a group of environmental risk factors: no access to an air-conditioned environment, living in homes with insufficient ventilation, outdoor working in hot places, residence in nursing homes, etc. (Vandentorren *et al.*, 2006; Abrahamson *et al.*, 2008). Those living in urban environments have a high risk of mortality, and since future population will become more urbanized, issue of heat-related mortality will probably become more severe (Almeida *et al.*, 2010). In relation to that, urban population would be effected by the heat waves in middle latitude areas as well as in northern regions. Most of the studies and projects of heat wave effects are for urban areas because of the high concentration of susceptible population and urban heat island effect (Kinney *et al.*, 2008). Additional urban environmental factors are living on the high floors of residential buildings (Hajat *et al.*, 2010), level of urbanization and cost of living (Smoyer *et al.*, 2000). Besides that, the most vulnerable groups are constituted of people with severe cardiovascular, cerebrovascular and respiratory diseases (Wilmshurt, 1994; Abrahamson *et al.*, 2008; Basu and Samet, 2002). The first at risk is population with low thermoregulation capacity (Kovats and Ebi, 2006). It is proven scientific fact that heat-related illnesses and mortality increase during heat waves (Kovats *et al.*, 2005).

Worldwide, adequate health protection of population from heat waves is defined through Heat Health Warning Systems (HHWS). There is a tendency to establish HHWS in all countries directly affected with extreme weather conditions. Consequently, reduction of heat wave effect on human health has been the main topic of numerous projects. For Europe, the most important were cCASHh (WHO, 2005), PHEWE (Michelozzi *et al.*, 2007) and EuroHEAT (WHO, 2009).

According to World Health Organization (World Health Organization, 2004), "Heat Health Warning System is defined as a system which uses meteorological forecasts to initiate public health interventions designed to reduce and mitigate heat-related impacts on human health during atypically hot weather." The HHWS is instrument for prevention of negative impacts of the thermal environment on human health during heat waves.

The first watch/warning system was initiated in 1995 in Philadelphia (Kalkstein *et al.*, 1996), followed by other USA cities. On the other hand, until 2001, only one HHWS was operational in Europe (Lisbon, Portugal). After that, World Meteorological Organization recommended Rome (Italy) to be pilot city for the next system to be established. Extremely warm summer of 2003 with numerous heat related deaths emphasized the need for creating HHWS across the continent. From 2006 onwards, HHWS became operational in the following countries – Spain, France, UK, Germany, Belgium, Switzerland, Hungary, Romania, the Netherlands, Macedonia and Greece (Lowe *et al.*, 2011; WHO, 2009).

In this paper, we researched the evidences for establishment of HHWS in Belgrade (Serbia) (Figure 1). Belgrade is the capital of Serbia and most populous and urbanized city in wider region. Metropolitan area of Belgrade has 1,659,440 inhabitants

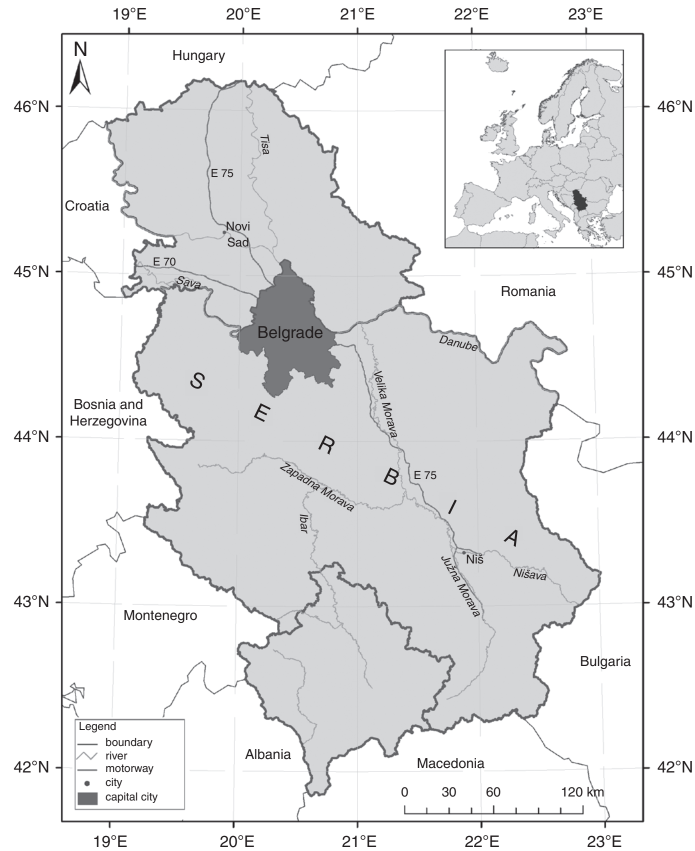


Figure 1.
Area of investigation – Belgrade (Republic of Serbia)

(Statistical Office of Republic of Serbia, 2012), while population density reaches 1,972 residents per built up area in km^2. We analyzed the impact of weather conditions on human health in Belgrade during the summer 2007. While summer 2003 was exceptionally hot for Western Europe, summer 2007 is characterized by heat wave episodes in Southeastern Europe (Founda and Giannakopoulos, 2009). In July 2007, period of extremely high temperatures lasted more than a week, and temperature records were broken on many stations in Serbia, including Belgrade. Poisson regression model was used to test relation between air temperature as predictor variable and mortality as depended variable. We considered cerebrovascular, cardiovascular and respiratory daily mortality counts, since people with those diseases are most susceptible to extreme heat. Also, we used three different heat wave indices and tested their ability to capture period with mortality higher than expected: the Warm Spell Duration index (WSDI) as function of daily maximum temperature (T_{max}), the consecutive days with daily minimum temperature (T_{min}) over estimated threshold and apparent temperature (T_{app}) which concerns temperature and humidity conditions.

HHWS

The development of a HHWS is a process which has number of necessary steps. The first is identification of weather conditions which affect human health. Since there is no unique definition of the terms "heat event" or "heat wave" (Robinson, 2001; Souch and Grimmond, 2004), the HHWS has to use different methods to identify such rare and extreme situations. The second component of the HHWS consists of weather forecasts and implementing mechanisms for issuing warnings in case that particular weather situation occurs (WHO, 2009). Finally, a process of prevention and intervention of heat-related health effects is based on the identification of population subgroups susceptible to heat and the surveillance of these persons during the summer months.

Defining of trigger threshold is one of the most important activities for the HHWS. Experts use different methods and measures to identify the level of heat effect on human health, with indicators which can be more or less complex. The simple measures use air temperature (T_{mean}, T_{max} or T_{min}) or a combination of temperature and humidity conditions (WHO, 2004). Until 2004, most of the countries used simple weather indices based on one or two climate elements. Temperature, humidity and/or wind speed data participate in complex indices such as apparent temperature, heat index, humidex, net effective temperature, wet-bulb-globe-temperature. Temperature or apparent temperature measures are used in the systems in several European countries such as Belarus, Belgium, France, Greece, Hungary, Latvia, Netherlands, Poland, Portugal, Romania, Spain, Switzerland and the UK (WHO, 2009). On the other hand, most of the complex indicators in the HHWS use synoptic weather classifications (Sheridan and Kalkstein, 2004) and heat budget models which use meteorological parameters to predict physiological heat load. For instance, the HHWS in Germany is based on perceived temperature (WHO, 2004), while synoptic based HHWS exist in USA, China, Canada and Italy.

The important part of every HHWS is warning procedure, which includes three steps: attention, alarm and emergency. WHO (2004) states that "the attention warning is given if a hot weather type is expected within the following 2 days. The alarm is given if the weather type is expected within the next 24–48 hours and the number of excess death is estimated at two or more. If the alarm situation persists for more than two days, an emergency is declared. The risk levels are not based on the numbers of excess deaths predicted because the system tends to underestimate the negative health effects in terms of mortality."

Data and methods

In order to evaluate the impact of extreme high summer temperatures and heat waves on human health, we analyzed the relation between daily mortality classified by causes of death and weather conditions in Belgrade during June, July and August 2007. The territory of Balkan Peninsula and Serbia was hit by several heat waves during summer 2007, with the strongest one in July. The Figure 2 shows the summer daily maximum temperature (T_{max}) in Belgrade from the second half of twenty century (1950-2010) with clearly visible peak (43.6°C), observed on July 24, 2007.

Meteorological data that we used include mean daily temperature (T_{mean}), maximum daily temperature (T_{max}), minimum daily temperature (T_{min}) and daily relative humidity for station Belgrade Meteorological Observatory ($\varphi = 44°48'$ N, $\lambda = 20°28'$ E, h = 132 m). Data were taken from Meteorological yearbooks published by Republic Hydrometeorological Service of Serbia (RHMSS).

In this study, we used daily mortality counts by three causes of death – cerebrovascular, cardiovascular and respiratory mortality, obtained from the Institute of Public Health, Belgrade. The Figure 3 shows mortality counts and mean temperature computed as five days running means during June, July and August 2007 in Belgrade. Running means are used to eliminate inter-daily variability and for better isolation of periods with low and high values of considered variables. There are three peaks of mortality

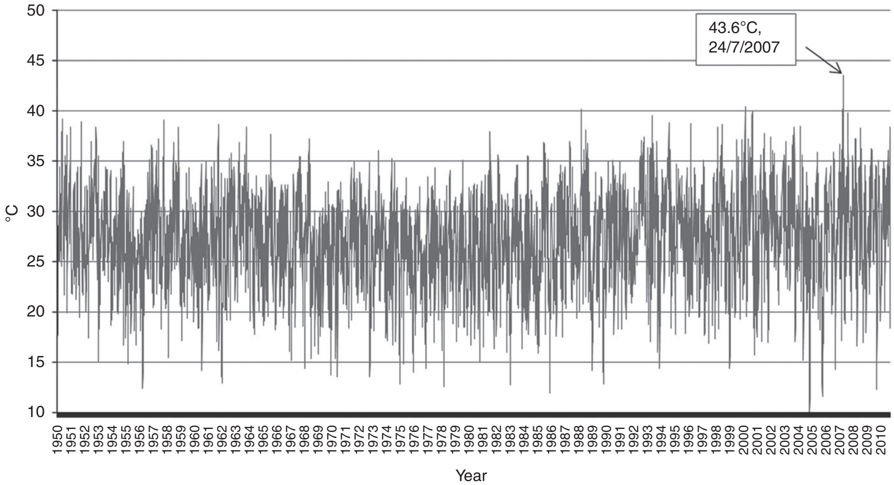


Figure 2.
Summer daily T_{max} in period 1950-2010 in Belgrade

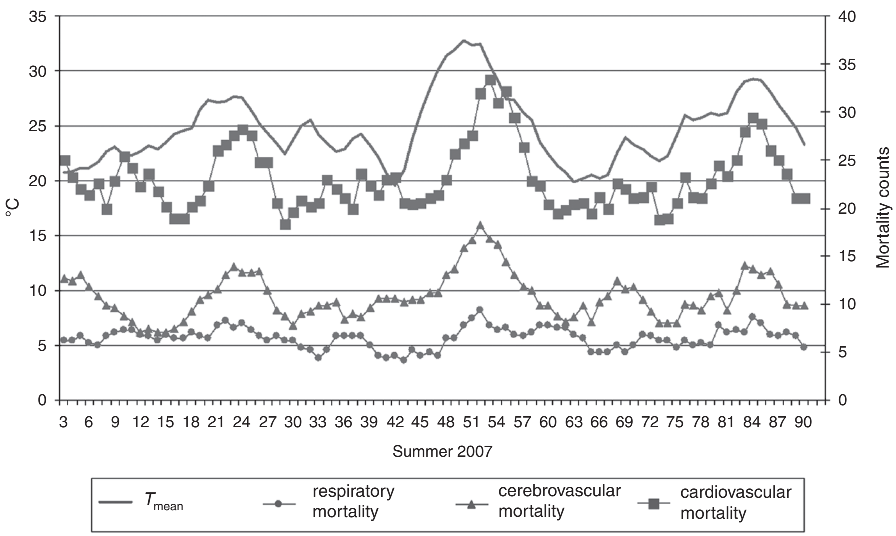


Figure 3.
The 5-days running means for mortality counts and T_{mean} during summer 2007 in Belgrade

and temperature in the same periods: in the second half of June, in middle of July and in the second half of August.

We were looking for two answers:

(1) Whether temperature variation can explain variation in mortality counts for three death causes (the most vulnerable groups)? We performed Poisson Generalized Linear Regression Model with mean daily temperature as predictor variable and mortality as depended variable. The model equation is Log (Mortality count) = Intercept + BxT_{mean}, where intercept and B is estimated regression parameters. In total, there are 92 time points (total number of days during summer). Descriptive statistics of model's inputs is presented in the Table I. All calculations were done in software SPSS 21.

(2) Whether some of existing indices "capture" the episodes with extreme mortality? In order to detect heat wave we used three different indices:

- WSDI as function of T_{max}. The WSDI is defined as period of at least six consecutive days when $T_{max} > 90$th percentile of daily T_{max} calculated for a 5-day window centered on each calendar day in the base period 1961-1990 (http://etccdi.pacificclimate.org/indices_def.shtml). The calculated threshold for 90th percentile of T_{max} is 30.7°C.
- In the second case, we used apparent temperature (T_{app}) as a person perceived temperature which concerns temperature and relative humidity. Mean daily apparent temperature was calculated as (Steadman, 1984; O'Neill *et al.*, 2003; D'Ippoliti *et al.*, 2010):

$$T_{app} = -2.653 + 0.994\,(T_{mean}) + 0.0153(T_{dewpt})^2$$

Where T_{mean} is mean daily temperature and T_{dewpt} is temperature of dew point. Using apparent temperature, we defined heat wave as period of at least two consecutive days with $T_{app} > 90$th percentile of daily summer distributions for period 2000-2010.

- The third index is defined as period of at least two consecutive days with T_{min} more than 90th percentile of daily distribution in the base period 1961-1990. The calculated threshold for 90th percentile of T_{min} is 19.5°C. This index was chosen because daily minimum temperatures during summer are important for human health (Unkašević and Tošić, 2009; Hajat *et al.*, 2002).

Results

We applied Poisson regression model on mortality counts and temperature data. Basic statistical model output is shown in the Table II. The results suggest that model fits

Model variables		n	Min.	Max.	Mean	SD
Dependent Variable	Cerebrobascular mortality	92	4	24	10.76	3.90
Dependent Variable	Cardiovascular mortality	92	11	42	23.09	6.20
Dependent Variable	Respiratory mortality	92	2	12	5.64	2.37
Covariate	T_{mean}	92	14.6	34.6	24.60	4.27

Table I. Descriptive statistics of modeled variables

Dependent variable		Goodness of Fit Value	df	Value/df
Cerebrovascular mortality	Deviance	93.883	90	1.043
	Pearson χ^2	95.557	90	1.062
	Log Likelihood	−238.714		
Cardiovascular mortality	Deviance	136.056	90	1.512
	Pearson χ^2	132.449	90	1.472
	Log Likelihood	−295.597		
Respiratory mortality	Deviance	88.456	90	0.983
	Pearson χ^2	87.705	90	0.974
	Log likelihood	−205.688		

Table II. Measures of goodness of fit well in the case of cerebrovascular and respiratory mortality counts (the ratio deviance/Pearson χ^2 and degrees of freedom is very close to 1), but there is in some degree over-dispersion in the case of cardiovascular deaths during summer 2007 (the ratio deviance/Pearson χ^2 and degrees of freedom is about 1.5).

Regression coefficients with p values are presented in Table III. The estimated parameters suggest that temperature has the highest impact on cerebrovascular deaths (estimated parameter value is 0.04, $p = 0.0001$). Only in case of respiratory mortality, estimated parameter for temperature is insignificant (confidential interval 90 percent). On the Figure 4, we presented scatter plots for predicted values of mean response and standardized deviance of residuals for all causes of deaths as confirmation that the used model has best fit for cerebrovascular deaths.

According to regression equation, a 1°C increase in T_{mean} is associated with a 4.6 percent ($p < 0.0001$), 2.2 percent ($p < 0.0001$) and 1.6 percent (insignificant for $p < 0.10$) in cerebrovascular, cardiovascular and respiratory mortality, respectively. Similar results got Almeida *et al.* (2010) for Lisbon (Portugal) – a 1°C increase lead to increase of 2.4 percent in case of cardiovascular mortality and 1.7 percent in respiratory mortality. During the extreme high temperatures in Christchurch (New Zealand), Hales *et al.* (2000) found that an increase of 1°C was associated with 1 percent increase in all-cause mortality and 3 percent increase in respiratory mortality. In case of London, when temperature reaches the most extreme values (97th percentile), an increase of 1°C is followed by 3.3 percent in all-cause mortality (Hajat *et al.*, 2002). In order to evaluate how extreme values of daily temperature impact daily mortality, the 90th percentile of T_{mean} during the summer of 2007 was calculated. All events were classified in two groups: those which happened when $T_{\text{mean}} <$ 90th and and those which happened during $T_{\text{mean}} \geqslant$ 90th percentile. Mortality is higher in average for 38.7 percent (cerebrovascular), 19.1 percent (cardiovascular) and 14.2 percent (respiratory) when the T_{mean} is $\geqslant$ 90th percentile compared to $T_{\text{mean}} <$ 90th.

Modeling the relation heat wave – human health requires better understanding of environmental factors and work on statistical model which operates with larger number of predictors as air pollution, socio-economic factors, etc. Unfortunately, for the moment, such data are not available for the researched area.

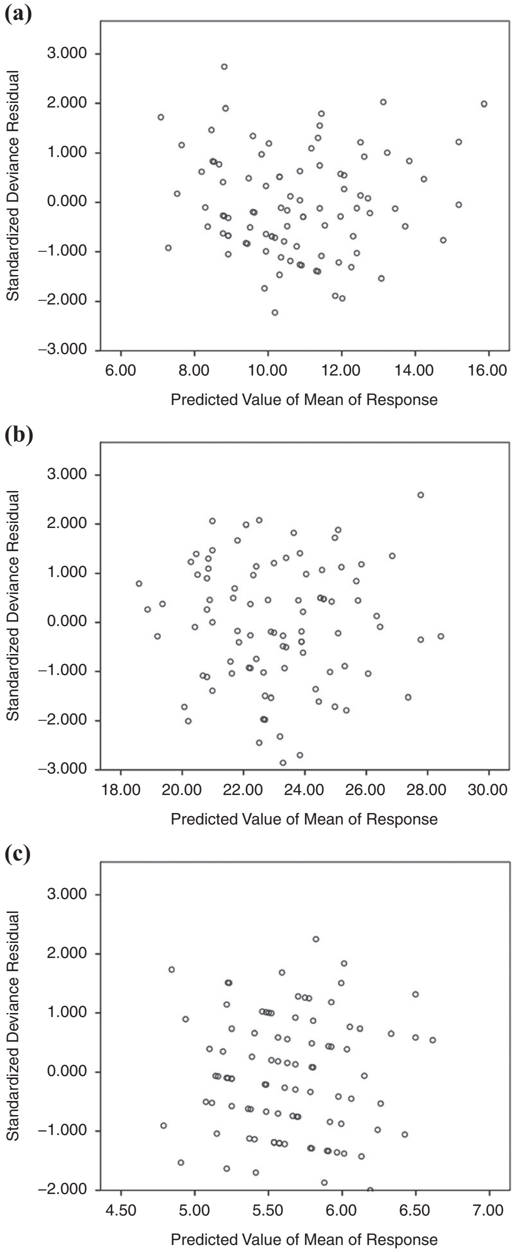
In the second part of study, we used three indices to "isolate" heat wave periods in the summer 2007. One of the major problems in dealing with heat waves is lack of generally accepted heat wave definition. With three different indices we included more weather parameters in analysis in order to get better estimation.

The periods under heat waves during summer 2007 are:

(1) The WSDI indicates two periods as heat wave: July 15-24 (ten days) and August 20-28 (nine days).

Table III.
Parameter estimates

				95% Wald Confidence Interval		Hypothesis Test		
	Parameter	B	SE	Lower	Upper	Wald χ^2	df	Sig.
Cerebro-vascular mortality	Intercept	1.369	0.1924	0.992	1.746	50.672	1	0.000
	T	0.040	0.0075	0.026	0.055	28.986	1	0.000
Cardio-vascular mortality	Intercept	2.613	0.1294	2.359	2.866	407.685	1	0.000
	T	0.021	0.0051	0.011	0.031	17.300	1	0.000
Respiratory mortality	Intercept	1.330	0.2608	0.819	1.842	26.027	1	0.000
	T	0.016	0.0103	−0.004	0.036	2.446	1	0.118



Notes: (a) Cerebrovascular; (b) cardiovascular; (c) respiratory deaths

Figure 4.
The scatter plots for predicted values of mean response and standardized deviance of residual

(2) The T_{app} indicates two periods as heat wave: July 17-22 (six days) and August 22-25 (four days).

(3) Index based on T_{min} indicates three periods as heat wave: June 19-26 (seven days), July 17-24 (eight days) and August 2 0-26 (seven days).

We can see that only index based on T_{min} "captures" heat wave in June 2007 and all of them recognized the heat waves in July and August with overlapping periods but with differences in duration. In general, these heat wave periods coincide with episodes of higher mortality visible on Figure 2. The Table IV shows the percentage (percent) of time with mortality higher than expected during the heat waves in summer 2007. The expected mortality is calculated as baseline value for five years period, since the only available data is for 2006-2010. The baseline mortality counts for cerebrovascular disease is 11.0, for cardiovascular 23.7 and for respiratory 6.3 dead. During the heat waves, the lowest percentage of time with mortality higher than expected are found for respiratory mortality. Probably, for better understanding of respiratory deaths, it is necessary to take into account other factors such as air pollution. But we can conclude that weather conditions are significant factor for cerebrovascular and cardiovascular deaths during summer 2007 in Belgrade. This is particularly evident when it is known that five year (2006-2010) daily maximum in cerebrovascular deaths (24 people) is recorded on 22 July 2007 during the heat wave episode.

Discussion

Heat waves have consequences on human health, including implication on many societal and economical aspects. This is especially pronounced in highly dense urban environments, with little or none green surfaces and complex network of transport and public services. The fact that 49.7 percent of central urban core is built up and 9.6 percent are green surfaces, makes Belgrade additionaly endangered by heat waves. Moreover, most of the work places are concentrated in urban core, with very frequent daily commute system.

In literature, old, poor, those living alone and sick are singled out as population groups that are especially vulnerable to high temperature during summer. Serbia has great share of old inhabitants and quite high share of poor. Specifically, when it comes to 2007, the demographic picture of Belgrade's population shows that share of those older than 65 years was 16.5 percent of total population. In the same year, according to the Living Standards Measurement Study, the percentage of poor was 6.6 percent (SORS, 2008). Additionally, inappropriate physical isolation of living environment, accompanied by social isolation magnifies negative heat effects on human health.

Table IV.
Percentage of time during heat waves with mortality higher than expected in summer 2007

Heat wave index	Period under heat wave	% of time with mortality higher than expected during heat wave		
		Cerebrovascular m.	Cardiovascular m.	Respiratory m.
WSDI	15-24 July	90	60	60
	20-28August	44.4	77.8	44.4
T_{min}	19-26 June	75	87.5	50
	17-24 July	100	75	62.5
	20-26 August	57.1	100	57.1
T_{app}	17-22 July	100	66.7	50
	22-25 August	75	100	50

Generally, the main information sources about the heat wave warning are available via mass media. During the middle of the June to the end of the summer 2007, media had almost everyday coverage about situation related to heat wave consequences in Serbia and Belgrade. The main source was Republic Hydrometeorological Service that spread out information through media. Additionally, the warning was given to the public via web site (www.hidmet.gov.rs/index.php), which is not efficient enough because majority of older and poor (susceptible population) have no internet access, making this service insufficient. According to printed media (newspapers with the biggest circulation – "Politika" and "Večernje novosti"), main topics were mostly about behavior instructions (or what to eat, drink, wear). Special protection is recommended for hronic patients. At the same time, climatologists and meterologists gave statements about effects of global warming and stressed that these situations will be more frequent in the future.

There are numerous evidences about social impact that heat wave 2007 had. Medical services had to intervene more that usual. For instance, during the night between 17 and 18 July, emergency line had 2,800 phone calls – which are 30 percent more than regular night (statement from Belgrade's Office of Emergency published on July 18th 2007 in newspaper "Politika"). The highest number of medical intervations was recorded on July 21st – 282 interventions or 20 percent more than July average and 23rd – 293 interventions or 25 percent more than July average and this is daily maximum for whole summer (Database, Belgrade's Office of Emergency, 2014). We recall that both of these days fall within episode of heat wave. Public hospitals had unfavorable conditions as there was lack of air conditioning which made situation even worse.

Another important indicator of stress that Belgrade's inhabitants endured is that Government had to give recommendation about working hours, which were shortened and did not encompass the hottest period of the day. There was special mention for those who work construction and all workers under open sky, with recommendation that in period from 11 am to 4 pm stop their activities. Also, public water supply system had good reaction and made available additional cistern stations in the various parts of the city with fresh water free of charge for those on the streets. City's water supply was about 7,800 l/sec (19.07.2007, "Politika") and it is illustrative that the average for July was 7,186 l/sec (6,955 l/sec for June and 6,791 l/sec for August), which is more than annual average of 6,681 l/sec (Database of Belgrade Waterworks and Sewerage, 2014). Also, power supply increased and sales of air conditioning were rised. More closely, Figure 5 shows that energy supply follows T_{mean} during the summer 2007 (Database of Electric Utility of Belgrade, 2014).

In the warning procedure, the biggest limit was absence of legislative. We emphasize the fact that "Law for protection from natural disasters and other hazards" (Official Gazzete of Republic of Serbia, 1994) created in 1977 was actual, without mention of climate change in any form. This is one of the reasons why reaction of the institutions was not appropriate, because 1977 Law did not predict special Body for proclaiming heat wave hazard. Based on current "Law of emergency situations" from 2009 (Official Gazzete of Republic of Serbia, 2012), National strategy for protection and rescue emergency of Republic of Serbia (Official Gazette of Republic of Serbia, 2011) was adopted and Southeastern Europe is defined as a risk area of all kinds of natural hazards. Although Strategy recognized heat wave as a hazard, there are no clear measures and actions for reducing the heat wave impacts on human health.

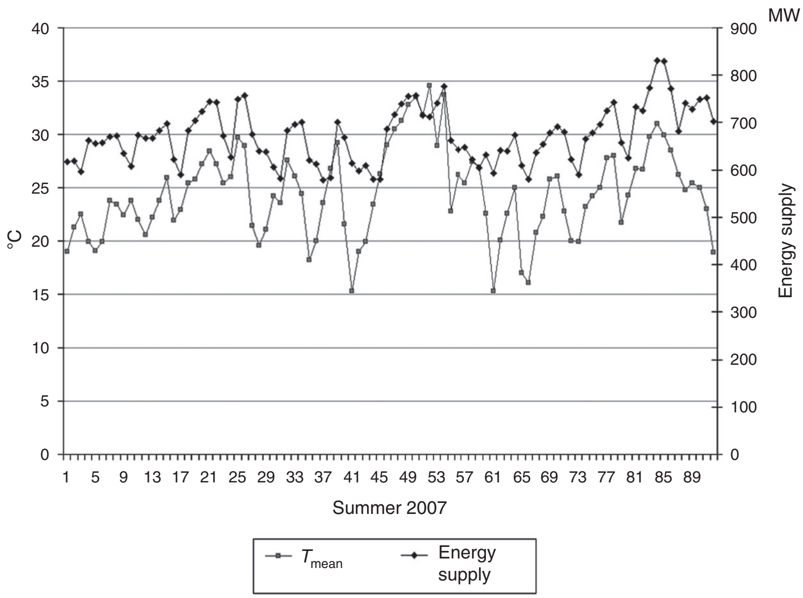


Figure 5.
T_{mean} and energy supply in Belgrade during summer 2007

As Poumadère *et al.* (2005) concluded, differences between pre-industrial and post-industrial countries when it comes to natural hazards is whether people or economy is mostly hit and who suffers the most. Since Serbia is transitional country, it is not surprising that the reaction to heat waves was not adequate, as post-industrial countries also had difficulties in mitigation of this phenomenon. For now, process of creating of HHWS in Serbia – Belgrade is quite slow even though there is obvious need as our research has shown.

Conclusions

There is no special document for initiating the HHWS in Serbia. This study is an attempt to evaluate the impact of heat waves on human health in Belgrade during the summer 2007. The capital of Serbia has high population density, considerable share of built up area and many multi floor buildings. Additionally, high concentration of single households and nursing homes is characteristic for Belgrade, which are factors of heat-health vulnerability. Moreover, the frequency of heat waves has been increasing since 1980s in Belgrade (Drljača *et al.*, 2009).

There is evidence that high temperatures affect human health in Belgrade, especially people who are suffering from cerebrovascular and cardiovascular diseases. The applied heat wave indices show good ability to recognize the periods with mortality higher than expected. Future research should include the other environmental factors as predictor variables in statistical models.

Although the Law recognizes heat wave as a natural hazard, the only one active subject in heat warning process is Republic Hydrometereological Service of Serbia. The "Law of meteorological and hydrological activity" (Official Gazette of Republic of Serbia, 2010) has emphasized that RHMSS should inform and warn public, emergency sector and other stakeholders about meteorological natural hazards via media. RHMSS has to predict possibility of extreme weather conditions, so that forecast information about heat wave could be found on: www.hidmet.gov.rs and www.meteoalarm.rs. Unfortunately, the Law contains no obligation in defining measures for reduction of heat wave effect on human health and mortality (Official Gazette of Republic of Serbia, 2010). Health and meteorological institutions are not in charge of unique monitoring system.

As a part of many heat health action plans, medical professionals have obligation to give specific advices to vulnerable population (Matthies and Menne, 2009). Raising awareness, behavioral and medical advice, providing information through the media, can be identified as a part of the most heat health plans. We can conclude that population living in Belgrade would benefit from establishment of the HHWS, especially vulnerable groups. Improvement of public health can be achieved if hazardous events as heat waves can be mitigated.

References

Abrahamson, V., Wolf, J., Lorenzoni, I., Fenn, B., Kovats, S., Wilkinson, P., Neil Adger, W. and Raine, R. (2008), "Perceptions of heatwave risks to health: interview-based study of older people in London and Norwich, UK", *Journal of Public Health*, Vol. 31 No. 1, pp. 119-126.

Almeida, S., Casimiro, E. and Calheiros, J. (2010), "Effects of apparent temperature on daily mortality in Lisbon and Oporto, Portugal", Vol. 9 No. 12, pp. 1-7, available at: www.ehjournal.net/content/pdf/1476-069X-9-12.pdf

Anderson, B. and Bell, M.L. (2009), "Weather-related mortality: how heat, cold, and heat waves affect mortality in the United States", *Epidemiology*, Vol. 20 No. 2, pp. 205-213.

Basu, R. and Samet, J. (2002), "Relation between elevated ambient temperature and mortality: a review of the epidemiologic evidence", *Epidemiologic Reviews*, Vol. 24 No. 2, pp. 190-202.

D′Ippoliti, D., Michelozzi, P., Marino, C., de'Donato, F., Menne, B., Katsouyanni, K., Analitis, A., Medina-Ramón, M., Paldy, A., Atkinson, R., Kovats, S., Bisanti, L., Schneider, A., Lefranc, A., Iñiguez, C. and Perucci, C.A. (2010), "The impact of heat waves on mortality in 9 European cities: results from the EuroHEAT project", *Environmental Health*, Vol. 9 No. 37, pp. 1-9, available at: www.ehjournal.net/content/pdf/1476-069X-9-37.pdf

Drljača, V., Tošić, I. and Unkašević, M. (2009), "Analysis of heat waves by means of the climate index in belgrade and niš", *Journal of the Geographical Institute "Jovan Cvijic" SASA*, Vol. 59 No. 1, pp. 49-62.

Fouillet, A., Rey, G., Laurent, F., Pavillon, P., Bellec, S., Ghihenneuc-Jouyaux, C., Clavel, J., Jougla, E. and Hémon, D. (2006), "Excess mortality related to the August 2003 heat wave in France", *International Archives of Occupational and Environmental Health*, Vol. 80 No. 1, pp. 16-24.

Founda, D. and Giannakopoulos, C. (2009), "The exceptionally hot summer of 2007 in Athens, Greece – A typical summer in the future climate?", *Global and Planetary Change*, Vol. 67 Nos 3/4, pp. 227-236.

Hajat, S., O'Connor, M. and Kosatsky, T. (2010), "Health effects of hot weather: from awareness of risk factors to effective health protection", *Lancet*, Vol. 375 No. 9717, pp. 856-863.

Hajat, S., Kovats, R.S., Atkinson, R.W. and Haines, A. (2002), "Impact of hot temperatures on death in London: a time series approach", *Journal of Epidemiology & Community Health*, Vol. 56 No. 5, pp. 367-372.

Hales, S., Salmond, C., Town, G., Kjellstrom, T. and Woodward, A. (2000), "Daily mortality in relation to weather and air pollution in Christchurch, New Zealand", *Australian and New Zealand Journal of Public health*, Vol. 24 No. 4, pp. 89-91.

Kalkstein, L.S., Jamason, P.F. and Greene, J.S. (1996), "The Philadelphia hot weather–health watch/warning system: development and application, summer 1995", *Bulletin of the American Meteorological Society*, Vol. 77 No. 7, pp. 1519-1528.

Kinney, P.L., O'Neill, M.S., Bell, M.L. and Schwartz, J. (2008), "Approaches for estimating effects of climate change on heat-related deaths: challenges and opportunities", *Environmental science & policy*, Vol. 11 No. 1, pp. 87-96.

Kovats, R.S. and Ebi, K.L. (2006), "Heatwaves and public health in Europe", *European Journal of Public Health*, Vol. 16 No. 6, pp. 592-599.

Kovats, R.S., Lendrum, D.C. and Matthies, F. (2005), "Climate change and human health: estimating avoidable deaths and disease", *Risk Analysis*, Vol. 25 No. 6, pp. 1409-1418.

Lowe, D., Kristie, L.E. and Forsberg, B. (2011), "Heatwave early warning systems and adaptation advice to reduce human health consequences of heatwaves", *International Journal of Environmental Research and Public Health*, Vol. 8 No. 12, pp. 4623-4648.

Matthies, F. and Menne, B. (2009), "Prevention and Management of health hazards related to heat waves", *International Journal of Circumpolar Health*, Vol. 68 No. 1, pp. 8-22.

Medina-Ramón, M., Zanobetti, A., Cavanagh, D.P. and Schwartz, J. (2006), "Extreme temperatures and mortality: assessing effect modification by personal characteristics and specific cause of death in a multi-city case-only analysis", *Environmental Health Perspectives*, Vol. 114 No. 9, pp. 1331-1336.

Meehl, G.A. and Tebaldi, C. (2004), "More intense, more frequent, and longer lasting heat waves in the 21st century", *Science*, Vol. 305 No. 5686, pp. 994-997.

Michelozzi, P., Kirchmayer, U., Katsouyanni, K., Biggeri, A., McGregor, G., Menne, B., Kassomenos, P., Anderson, H.R., Baccini, M., Accetta, G., Analytis, A. and Kosatsky, T. (2007), "Assessment and prevention of acute health effects of weather conditions in Europe, the PHEWE project: background, objectives, design", *Environmental Health*, Vol. 6 No. 12.

Naughton, M.P., Henderson, A., Mirabelli, M.C., Kaiser, R., Wilhelm, J.L., Kieszak, S.M., Rubin, C.H. and McGeehin, M.A. (2002), "Heat related mortality during a 1999 heat wave in Chicago", *American Journal of Preventive Medicine*, Vol. 22 No. 4, pp. 221-227.

O'Neill, M.S., Zanobetti, A. and Schwartz, J. (2003), "Modifiers of the temperature and mortality association in seven US cities", *American Journal of Epidemiology*, Vol. 157 No. 12, pp. 1074-1082.

Official Gazzete of Republic of Serbia (1994), "Law for protection from natural disasters and other hazards", available at: www.vatroival.com/doc/propisi/OZR/Zakon%20o%20za%C5%A1titi%20od%20elementarnih%20i%20drugih%20vecih%20nepogoda.pdf (accessed October 20, 2013).

Official Gazette of Republic of Serbia (2010), "The Law of Meteorological and Hydrological Activity", available at: www.hidmet.gov.rs/podaci/download/zakon_o_met_i_hid_delatnosti.pdf (accessed September 2, 2013).

Official Gazette of Republic of Serbia (2011), "National strategy for protection and rescue emergency of Republic of Serbia", available at: www.mup.gov.rs/cms_lat/sadrzaj.nsf/Nacionalna_strategija_zastite_i_spasavanja_u_vanrednim_situacijama_lat.pdf (accessed September 2, 2013).

Official Gazzete of Republic of Serbia (2012), "Law of emergency situations", available at: www.mup.gov.rs/cms/resursi.nsf/Zakon%20o%20vanrednim%20situacijama-lat.pdf (accessed October 20, 2013).

Poumadère, M., Mays, C., Le Mer, S. and Blong, R. (2005), "The 2003 heat wave in France: dangerous climate change here and now", *Risk Analysis*, Vol. 25, pp. 1483-1494.

Robine, J.M., Cheung, S.L.K., Le Roy, S., Van Oyen, H., Griffiths, C., J-Pierre, M. and François, R.H. (2008), "Death toll exceeded 70,000 in Europe during the summer of 2003", *Comptes Rendus Biologies*, Vol. 331 No. 2, pp. 171-178.

Robinson, P.J. (2001), "On the definition of a heat wave", *Journal of Applied Meteorology*, Vol. 40 No. 4, pp. 762-775.

Semenza, J.C., Rubin, C.H., Falter, K.H., Selanikio, J.D., Flanders, W.D., Howe, H.L. and Wilhelm, J.L. (1996), "Heat-related deaths during the July 1995 heat wave in Chicago", *The New England Journal of Medicine*, Vol. 335 No. 2, pp. 84-90.

Sheridan, S.C. and Kalkstein, L.S. (2004), "Progress in heat-watch warning system technology", *American Meteorological Society*, Vol. 85 No. 12, pp. 1931-1941.

Smoyer, K.E., Rainham, D.G.C. and Hewko, J.N. (2000), "Heatstress- related mortality in five cities in Southern Ontario: 1980-1996", *International Journal of Biometeorology*, Vol. 44 No. 4, pp. 190-197.

Souch, K. and Grimmond, C.S.B. (2004), "Applied climatology: 'heat waves'", *Progress in Physical Geography*, Vol. 28 No. 4, pp. 599-606.

Statistical Office of the Republic of Serbia (2012), "2011 Census of population, households and dwellings in the Republic of Serbia. Book No. 2. Age and sex", available at: http://pod2.stat.gov.rs/ObjavljenePublikacije/Popis2011/Starost%20i%20pol-Age%20and%20sex.pdf (accessed September 2, 2013).

Steadman, R.G. (1984), "A universal scale of apparent temperature", *Journal of Climate and Applied Meteorology*, Vol. 23 No. 12, pp. 1674-1687.

Unkašević, M. and Tošić, I. (2009), "An analysis of heat waves in Serbia", *Global Planet Change*, Vol. 65 Nos 1/2, pp. 17-26.

Vandentorren, S., Bretin, P., Zeghnoun, A., Mandereau-Bruno, L., Croisier, A., Cochet, C., Ribéron, J., Siberan, I., Declercq, B. and Ledrans, M. (2006), "August 2003 heat wave in France: risk factors for death of elderly people living at home", *European Journal of Public Health*, Vol. 16 No. 6, pp. 583-591.

Wilmshurt, P. (1994), "Temperature and cardiovascular mortality. Excess deaths from heart disease and stroke in northern Europe are due in part to the cold", *British Medical Journal*, Vol. 309 No. 6961, pp. 1029-1030.

World Health Organization (2004), "Heat-waves: risks and responses", Health and Global Environmental Change, Vol. 2, available at: www.euro.who.int/__data/assets/pdf_file/0008/96965/E82629.pdf (accessed August 24, 2013).

World Health Organization (2005), "Health and climate change: the now and how. A policy action guide", World Health Organization, Copenhagen.

World Health Organization (2009), "Improving public health responses to extreme weather/heat-waves-EuroHEAT, technical summary", available at: www.euro.who.int/__data/assets/pdf_file/0009/95913/E92473.pdf (accessed August 28, 2013).

Further reading

Statistical Office of the Republic of Serbia (2008), "Living standards measurement study Serbia 2002-2007", available at: www.inkluzija.gov.rs/wp-content/uploads/2011/09/Book.pdf (accessed January 16, 2014).

World Health Organization (2007), "Meeting report: improving public health responses to extreme weather/heat-waves – euroHEAT", Bonn, 22-23 March.

Corresponding author

Gorica B. Stanojević can be contacted at: g.stanojevic@gi.sanu.ac.rs