Daily mortality counts and summer heat waves in Belgrade (Serbia)

Jelena Stojilković, Vlasta Kokotović, Gorica Stanojević and Aleksandra Spalević

Geographical Institute "Jovan Cvijić" of the Serbian Academy of Sciences and Arts, Đure Jakšića 9, Belgrade, Serbia

There are numerous factors affecting human health, some of which behavioral, some environmental. It is historically known fact that weather and climate can have significant effect on human health and activities. There are well documented proofs that mortality increases during heat wave and extreme high temperature (Basu, 2009; Basu and Samet, 2002). Since the intensity and frequency of extreme temperature events increased in last decades of the twenty century (Frich et al., 2002; Moberg et al., 2006), it is especially important to examine high temperature impact on human health and mortality. In recent decades many European regions are being affected by unusually high summer temperatures (Kyselý, 2002). Extremely high temperatures are environmental factor that can have pronounced negative consequences on population even in the 21th century, as excess mortality during summer 2003 in Western Europe has proved. The aim of this research is to assess the relation between heat waves and daily mortality counts in Belgrade (Serbia) during the summer months in period 2000-2010, with emphasize on exceptionally hot summer of 2007. Belgrade, capital of Serbia, is located in the north central part of country and Balkan Peninsula. The Metropolitan Belgrade (45°05` N - 44°15` N and 19°58` E - 20°51` E), covers 3,233.94 km² with 1,659,440 inhabitants (Statistical Office of Republic of Serbia 2012). Population density is around 513 inhabitants per km², apropos 1,972 per built up area (km²). We used two different measures of heat waves in order to test which one better identifies days affected by heat wave and mortality higher than expected: Warm Spell Duration Index (WSDI) based on air temperature and apparent temperature (Tapp), which uses the temperature and humidity conditions. Poisson distribution was used to model mortality data in summer months and cumulative probability to define three thresholds (90th, 95th and 99th percentile) for daily extreme mortality counts. The threshold probability for 90th percentile (10% probability for death occurrence) during summer season was 65 death counts, for 95th (5%) was 68 deaths and 99th percentile of daily mortality (1%) would happened if mortality surpasses 72 dead. The expected baseline mortality is average mortality for investigated period (55.3 persons/day). The results show that in most cases the WSDI and Tapp include days with mortality higher than expected (55.3 persons/day). In total, 75.7% of overall time duration that WSDI identified as heat wave period and 88.5% time of Tapp cover days with mortality higher than expected in analyzed period. Two main factors for extreme mortality counts are duration and intensity of heat wave. Prolonged period with extreme temperature and higher daily average temperature excess are the main factors for episodes with mortality more than certain thresholds (90th, 95th and 99th percentile). In order to demonstrate this, we chose five heat wave episodes for graphical interpretations of daily values of Tmax and Tapp and mortality within calendar months in these heat waves happened (Figure 1-5). In all cases, extreme mortality counts during several consecutive days happened within the WSDI and Tapp which lasting and intensity were higher than usual. Similar results were obtained for other cities in Europe (D'Ippoliti et al., 2010). Additionally, during period which WSDI index identified as period of heat wave, in every episode out of five, mortality was higher than expected. In heat wave during August in 2000 and "second" heat wave in 2007, also during August, these increase in mortality were modest (about 13% on average), but, "first" heat wave in 2007 during July, and two in 2008 and 2010 (both in June), had much more pronounced effect on mortality increase (20% on average). Other index, Tapp shows also that mortality was higher than expected in all episodes, but increase was even greater than those in WSDI. For numbered lists the WSDI and Tapp events with the highest duration and intensity overlapped and occurred in the same calendar days. The Tapp had on the average shorter duration than WSDI and positioned within the WSDI event. The most extreme mortality episode was recorded during the heat wave in July 2007. Heat wave is observed in period 15-24 July and 17-22 July for WSDI and Tapp respectively. During the heat wave in July 2007 on many stations in Serbia temperature records were broken. In Belgrade, the absolute temperature record of 43.6°C was reached on 24 July 2007. That day, mortality count had the highest value (94 persons) in the whole analyzed period. During the WSDI (Tapp) 7 (5) days had mortality counts more that 90^{th} and 95^{th} percentile and 5 (4) days more than 99^{th} percentile. The average mortality counts for men are higher than for women (29.2 : 26.1), with long-term mean difference between men and women of 3.1. This relation stays constant for most time of heat waves. Exceptions are the most severe events, when the average mortality per day for women is higher than for men. In Serbia, long-term trends show future increase of old population and continued process of demographic aging (Stojilković, 2011). Alongside old population, the most susceptible groups encompass people with cardiovascular and celebrovascular diseases. Increasing trend in mortality of given diseases requires defining rapid strategies and activities for mortality reduction, especially in light of heat-related mortality.

Acknowledgments

This paper is a part of scientific project 47007 supported by Ministry of Education, Science and Technological Development of the Republic of Serbia.

References

Basu, R. (2009). *High ambient temperature and mortality: a review of epidemiologic studies from 2001 to 2008*. Environmental Health, 8, 40. doi:10.1186/1476-069X-8-40

Basu, R. and Samet, J. (2002). *Relation between elevated ambient temperature and mortality: A review of the epidemiological evidence*. Epidemiologic Reviews, 24, 190-202. doi: 10.1093/epirev/mxf007

D'Ippoliti, D., Michelozzi, P., Marino, C., de'Donato, F., Menne, B., Katsouyanni, K.,...Perucci, C. (2010). *The impact of heat waves on mortality in 9 European cities: results from the EuroHEAT project*. Environmental Health, 9, 37. doi:10.1186/1476-069X-9-37

Frich, P., Alexander, L.V., Della-Marta, P., Gleason, B., Haylock, M., Klein Tank, A.M.G., Peterson, T. (2002). *Observed coherent changes in climatic extremes during the second half of the twentieth century*. Climate Research, 19, 193-212. doi:10.3354/cr019193

Moberg, A., Jones, P.D., Lister, D., Walther, A., Brunet, M., Jacobeit, J... Xoplaki E. (2006). *Indices for daily temperature and precipitation extremes in Europe analyzed for the period 1901–2000*. Journal Geophysical Resreach, 111(D22) 106. doi: 10.1029/2006JD007103

Kyselý, J. (2002). *Probability estimates of extreme temperature events: Stochastic Modelling Approach vs. extreme value distributions*. Studia Geophysica et Geodaetica, 46, 93-112. doi: 10.1023/A:1019841717369

Stojilković, J. (2011). *Growing number of pensioners and population ageing in Serbia*. Journal of the Geographical Institute "Jovan Cvijić" SASA, 61, 69-84. doi: 10.2298/IJGI1102069S

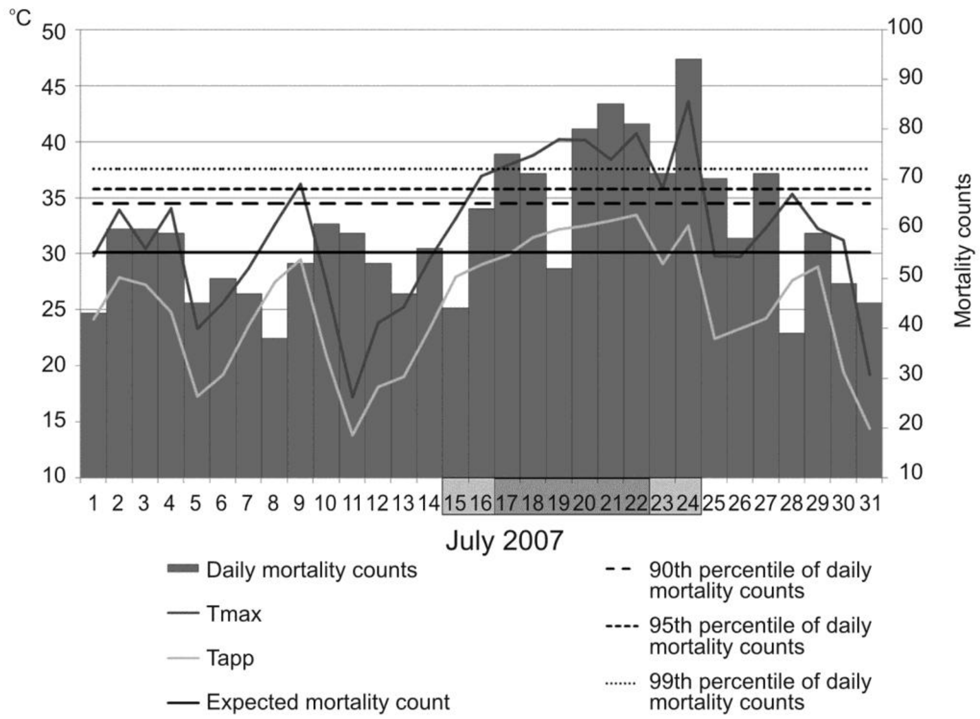

Figure 1. Daily mortality counts, Tmax and Tapp with thresholds for expected mortality and 90th, 95th and 99th percentile of daily mortality counts in July 2007. The WSDI is observed in period 15-24 July 2007 and Tapp is observed in period 17-22 July 2007 (the dates are marked on x-axis).

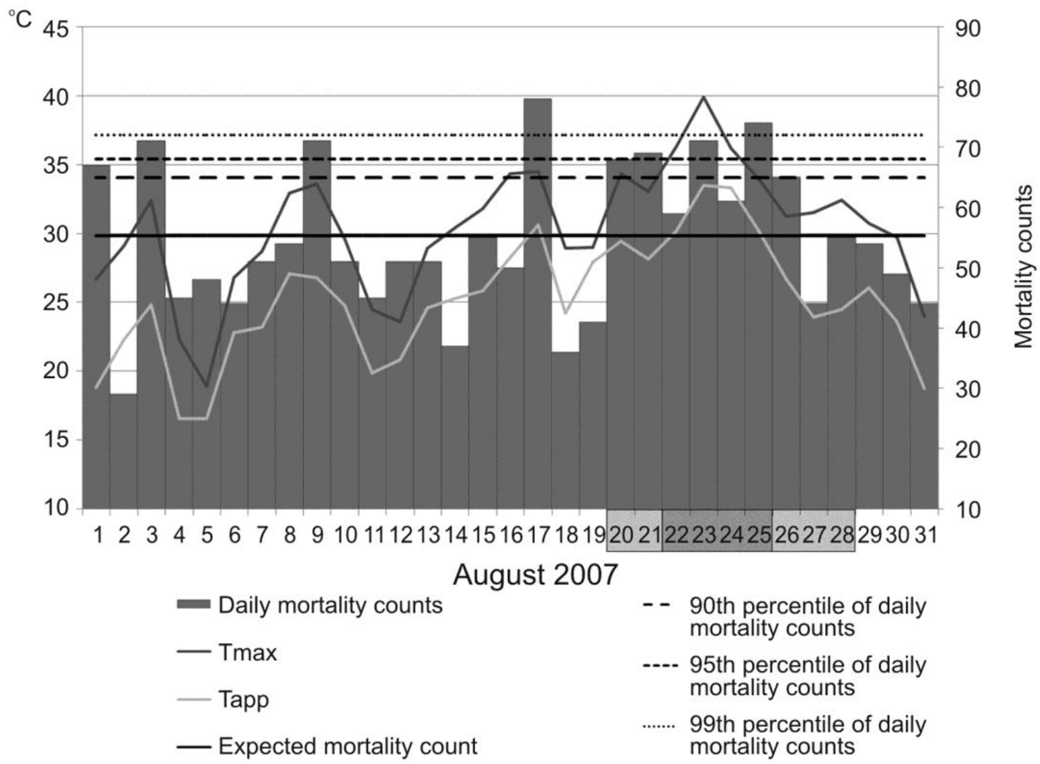

Figure 2. Daily mortality counts, Tmax and Tapp with thresholds for expected mortality and 90th, 95th and 99th percentile of daily mortality counts in August 2007. The WSDI is observed in period 20-28 August 2007 and Tapp is observed in period 22-25 August 2007 (the dates are marked on x-axis).

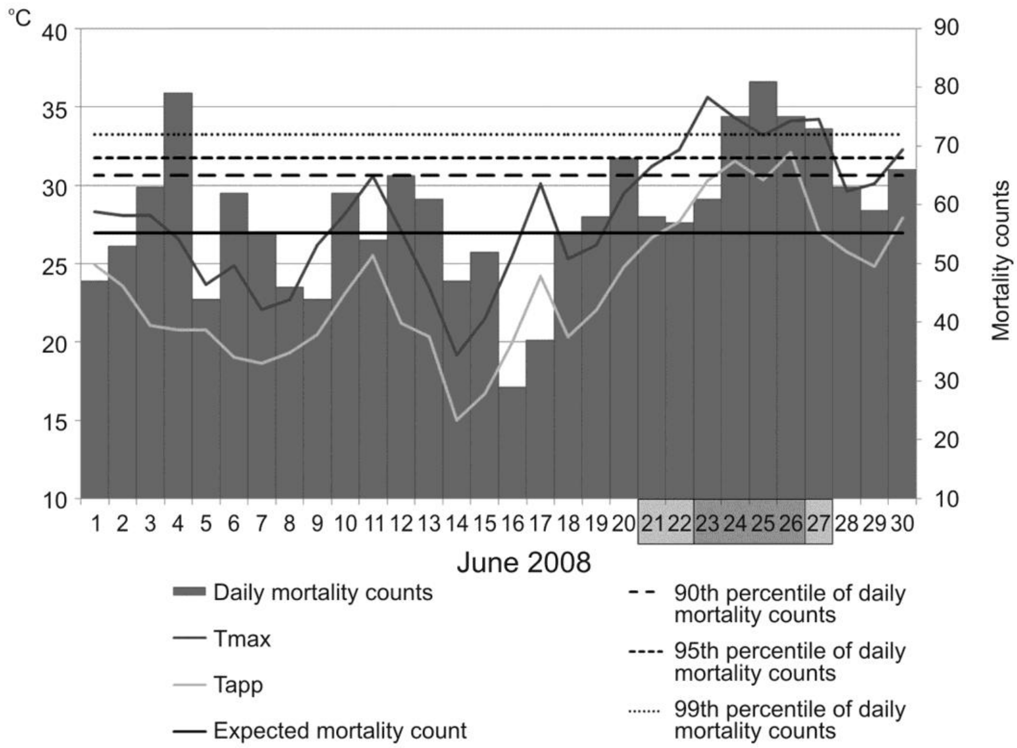

Figure 3. Daily mortality counts, Tmax and Tapp with thresholds for expected mortality and 90th, 95th and 99th percentile of daily mortality counts in June 2008. The WSDI is observed in period 21-27 June 2008. and Tapp is observed in period 23-26 June 2008 (the dates are marked on x-axis).

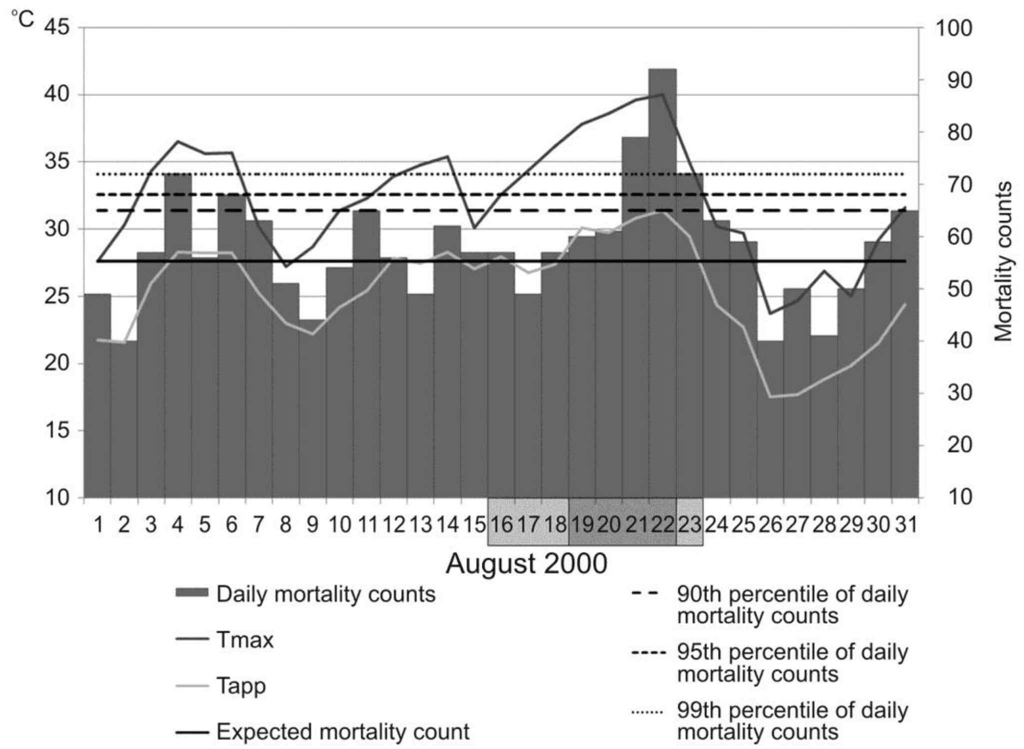

Figure 4. Daily mortality counts, Tmax and Tapp with thresholds for expected mortality and 90th, 95th and 99th percentile of daily mortality counts in August 2000. The WSDI is observed in period 16-23 August 2000. and Tapp is observed in period 19-22 August 2000 (the dates are marked on x-axis).

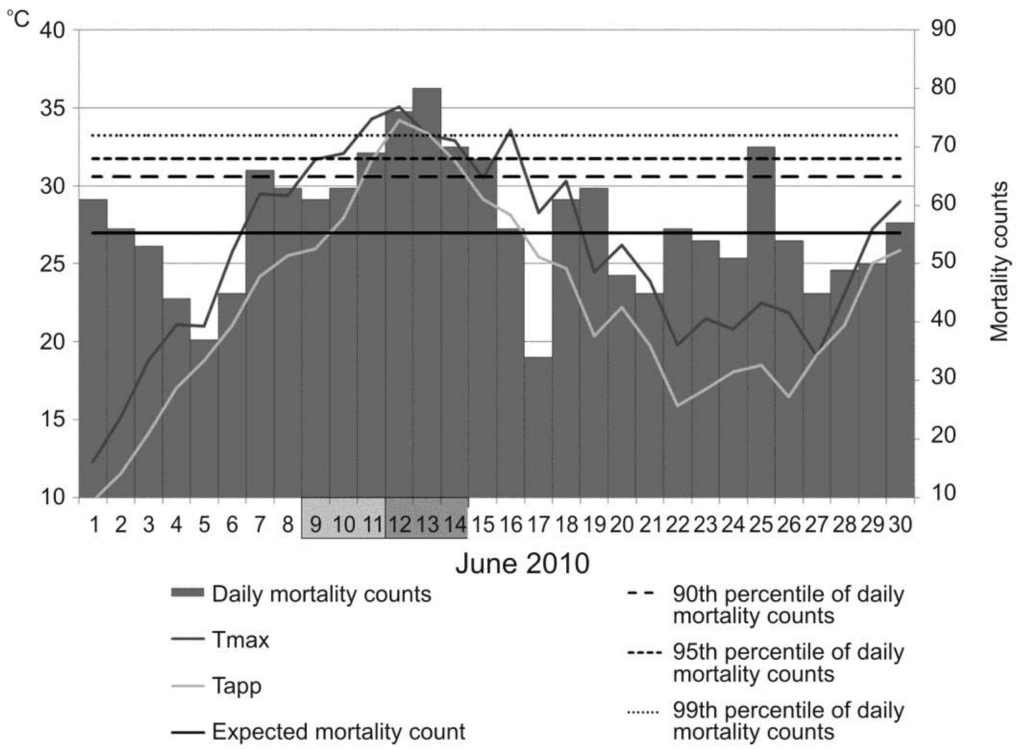

Figure 5. Daily mortality counts, Tmax and Tapp with thresholds for expected mortality and 90th, 95th and 99th percentile of daily mortality counts in June 2010. The WSDI is observed in period 9-14 June 2010. and Tapp is observed in period 11-14 June 2010 (the dates are marked on x-axis).