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# Exploring the association between bioclimatic indices and cardiovascular mortality: Preliminary results from Northern Greece

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It is well-established that exposure to extreme ambient temperatures is linked to adverse health effects associated with cardiovascular and respiratory diseases. Epidemiological studies demonstrate that the relationship between air temperature and mortality is depicted as a "U", "V" or "J" shaped curve where the lower extrema reflect the comfort zone and mortality rises beyond a temperature threshold that is region- and population-specific and depends on various socioeconomic factors. However, temperature is not the only parameter determining thermal stress, as relative humidity, wind speed and other meteorological parameters are also known to play an important role which is often ignored. This study investigated the relationship between mortality and thermal conditions in the region of Northern Greece, using several bioclimatic indices as indicators. The data used included mean daily values of air temperature, relative humidity and wind speed and daily mortality counts due to cardiovascular diseases for the time-period 2010-2018. The following 3 thermal indices were estimated: (a) Effective Temperature (ET), (b) Normal Effective Temperature (NET) and (c) Apparent Temperature (AT). These indices were selected as they depend on typically measured variables and they can describe thermal comfort in both warm and cold environments. The association between each thermal index and mortality was studied by fitting a Poisson regression model for over-dispersed data, combined with a distributed lag non-linear model. In order to detect delayed adverse effects of low temperatures, the lag period was extended to 21 days. A "U" shape curve was found to describe the relationship between each thermal index examined and mortality, indicating the existence of a cold and a hot threshold. Thresholds were identified at 16.6$^{o}$C and 31.3$^{o}$C for AT, at 16.1$^{o}$C and 25.5$^{o}$C for ET and at 13.7$^{o}$C and 24.3$^{o}$C for NET. Exposure to high temperatures was found to be more hazardous compared to low temperatures. The cardiovascular mortality risk increased by 8%, 14% and 10% for each additional degree above the AT, NET and ET hot threshold, respectively. On the other hand, a degree below the AT cold threshold resulted in 1% rise in the mortality risk and 2% rise for the case of ET and NET. Furthermore, the thresholds identified for the bioclimatic indices were used to identify temperature thresholds. In all cases the cold temperature threshold lied between 18.1$^{o}$C and 20.7$^{o}$C, confirming that cold-mortality is not necessarily linked to the lowest temperatures. The hot temperature threshold was almost the same in all cases; 27.6$^{o}$C for AT and NET and 27.7 for ET. On the whole, this study confirms the complexity of climate-health

associations and highlights the importance of bioclimatic indices as tools to evaluate thermal stress and to feed adverse health effect prevention strategies.

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