

The burden of heat-related mortality in Madrid: a hundred-year journey

Diego Ramiro

Institute of Economy, Geography y Demography
Spanish National Research Council
Madrid, Spain
diego.ramiro@cchs.csic.es

Dariya Ordanovich

Institute of Economy, Geography y Demography
Spanish National Research Council
Madrid, Spain
dariya.ordanovich@cchs.csic.es

Aurelio Tobias

Institute of Environmental Assessment and Water Research
Spanish National Research Council
Barcelona, Spain
aurelio.tobias@idaea.csic.es

Stanislao Mazzoni

Institute of Economy, Geography y Demography
Spanish National Research Council
Madrid, Spain
Stanislao.mazzoni@cchs.csic.es

Abstract

Background. The association between ambient temperatures and health outcomes was extensively studied in the past decades, especially in the light of exacerbating climate change. Yet long-term studies focusing on the analysis of the changes of mortality answers to extreme heat are rare, particularly in the Mediterranean region. *Minimum Mortality*, or so-called *Optimum* temperatures are increasingly used to assess the levels of adaptation to changing temperatures. The warming of the air temperatures in Spain affected the entire national territory since the turn of the XX century. However, the number of studies exploring the evolution of adaptation to heat and relying on multidecadal time-series data in Spain at any administrative level is very limited. To our knowledge, the present research is the first one to leverage daily mortality and temperature data in the city of Madrid since the end of the XIX century until today.

Methods. We examined the patterns of adaptation to extreme heat in the city of Madrid in the period from 1890 until 2020 using daily data on air temperature received from the meteorological stations and all-cause mortality from yearly books and civil registers. Using a distributed-lag nonlinear modelling approach we explored the complex heat-mortality relations and estimated the changes in the adaptation metrics by decade.

Expected results. Based on the previous research by the authors performed at different spatial levels in Spain for shorter time periods, we expect to see a gradual increase in the optimum temperatures over time, along with the overall increment of the air temperatures, especially in the last decades. We also expect to see a general reduction

in the heat-attributable mortality fractions, which would indicate a progressive adaptation to overall warming of air temperatures and intensification of weather extremes. On the other hand, the dose-response relationship is expected to differ between sex- and age-groups, being supposedly the highest for older woman and children in the beginning of the study period. We expect a spatially different response of mortality to intense heat within the city due to different housing environment and development of urban infrastructures in each area of the city.

Keywords Mortality · Heat · Distributed-lag nonlinear model · Adaptation