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Weather and climate versus mortality in Lisbon (Portugal) since the 19th century

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A B S T R A C T

A renewed interest on the impacts of climate change has spurred several studies on climate/health relationships. This study aims to detect and explain any changes in the relationships between climate and mortality in Lisbon from 1835 until 2012. The evaluation of mortality seasonal rhythms over time is based on the 100-Index per decades, annual Winter-Summer ratio, as well as other descriptive statistics. A change in the seasonal rhythm of mortality over the last 177 years was found. In the mid-19th century mortality peaked in summer, whereas in the 1890s and the 1900s there was slight monthly variability. On the contrary, a winter maximum has occurred since the 1940s, although a secondary summer peak of mortality may emerge during the most severe heat-waves. Although long term positive temperature trends were confirmed, no systematic positive mortality trends were found in the last three decades. The results suggest that mortality rhythm changes during the 19th and 20th century are not directly related to climatic reasons alone (except in the case of extreme weather events), but rather to improvements in hygienic, sanitary and nutrition conditions and advances in medicine. However, given the possible increase of summer heat waves in the future, and individuals increasing vulnerability, particularly in urban areas, such secondary peaks of mortality will tend to happen more frequently, unless adaptation of populations to hotter conditions takes place and/or measures are taken to protect people from high temperatures.

Introduction

The influence of weather on human health has been recognized as early as the 5th–4th century BC by Hippocrates. The current discussion on climate change, particularly the global warming issues and the foreseen possible negative impacts on public health, has caused a renewed interest in these topics (Huang et al., 2011; McMichael & Lindgern, 2011; Woodward et al., 2014). Some publications suggest that extreme weather events, such as heat waves, are (and will be) one of the main causes of high mortality peaks (Intergovernmental Panel on Climate Change [IPCC], 2012, 2013; Johnson & Wilson, 2009; Kovats & Hajat, 2008; Waylen, Keellings, & Qiu, 2012), e.g. the 2003 European heat wave and the 2010 Russian heat wave that resulted in tens of thousands of deaths (Robine, Cheung, Le Roy, Van Oyen, & Herrmann, 2007). Hajat and Kosatky (2010) studied 64 sites in different geographic settings and have shown that "in almost half the locations, the risk of mortality increased between 1% and 3% per 1 °C change in (…) temperature". This study has been carried out mainly in urban areas that house 51.6% of world population; 10.2% of the urban population is over 60 years of age (United Nations [UN], 2013) and hence particularly vulnerable to extreme weather events (European Environment Agency [EEA], 2012). Moreover, the urban heat island effect enhances the temperature rise (Alcoforado & Andrade, 2008; Barata et al., 2011; Merbitz, Buttstädt, Michael, Dott, & Schneider, 2012). A recent temperature increase has been detected in most continental areas of the Northern hemisphere (IPCC, 2013) and it is expected that mortality will increase with progressive warming of the

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atmosphere (Almeida, Casimiro, & Calheiros, 2010; Hajat, Vardoulaldis, Heaviside, & Eggen, 2014). Moreover, according to Casimiro, Calheiros, Santos, and Kovats (2006), mortality caused by high temperatures in Lisbon (Portugal) will increase from 5.8 to 6 deaths per 100,000 inhabitants (in 1980–88) to 8.5–12.1 in 2020 and to a maximum of 29.5 in 2050, if no adaptation takes place. According to Hajat and Kosatky (2010) "measures designed to minimize heat islands in cities, to keep the interiors of buildings cool and to improve the general care of the elderly are likely to play a key role in reducing future heat burdens".

On the contrary, other authors state that there is insufficient evidence that climate change (more precisely global warming) has been affecting human health (Deschenes, 2012; Dessai & Hulme, 2004; Ebi, 2014; Harlan & Ruddell, 2011; McMichael & Lindgern, 2011; Wardekker, Jong, Bree, Turkenburg, & Sluijs, 2014). According to Deschenes (2012), the empirical identification of the response function linking extreme temperatures to health is difficult due to the nonlinearity and heterogeneity of the response functions. These can reflect complex relationships, misconstructions due to omitted variables bias, and secular or seasonality changes over time and across countries. Furthermore, very little is known about the health-preserving effects of adaptation in response to extreme temperatures.

Carson, Hajat, Armstrong, and Wilkinson (2006) showed that in London "there was a progressive reduction of temperature related deaths over the 20th century, despite an ageing population". The authors conclude that this trend reflects more favourable environmental, social and health care conditions. In accordance with the latter, Goklany (2009) states that the decreasing trend of mortality in the U.S. is mostly related with the reduction of vulnerability and Barreca, Clay, Deschenes, Greenstone, and Shapiro (2013) found "that the mortality effect of an extremely hot day declined by about 80% between 1900–1959 and 1960–2004" in the U.S., partly due to the use of domestic air conditioning.

Furthermore, the relationship weather/mortality is not stable in time and depends also on the seasons. Any research on this topic must look into the seasonality of mortality rates and to compare them with changing temperature rates. Rau (2007) showed that mortality seasonality changes in place and in time. Since the mid 19th century a Winter maximum has occurred in most North-European and North-American countries. In half a century (between 1870 and 1920) this seasonal pattern changed in the U.K. into a Winter peak and a Summer low (Rau, 2007). This shift in such a short period is most probably due a "considerable improvement in hygiene which almost completely eradicated intestinal diseases" (Rau, 2007:30–31) and not necessarily to climate change alone.

Lisbon is located at 38°43′ latitude N and it lies on a hilly area on the northern bank of the Tagus estuary, 30 km to the east of the Atlantic (Fig. 1). Its climate is 'Mediterranean', with a dry Summer and rainfall occurring mostly in the cold season. Throughout the 20th century the social, economic and demographic changes were particularly significant in consequence of a fast moving urbanization process.

The main objectives of this paper are: (i) to retrieve mortality and climatic data of the early 19th century in Lisbon; (ii) to compare the seasonal rhythm of mortality and climatic variables over time and (iii) to look for causal relationships between climate and mortality and investigate if they have changed over time.

Data is described in the next section, followed by the methodology selected to assess seasonality of mortality and temperature trends throughout time and by the Results Section. The results are analyzed in Discussion Section and the main conclusions are presented in the last section.

Data and methods

Meteorological and mortality data pertaining to the early 19th century were compiled by Marino Miguel Franzini, a military, scientist and politician who restarted meteorological observations in Lisbon in the early 19th century, at the request of Bernardino Gomez, a doctor who strived to understand why the seasonal patterns of mortality in Portugal (attaining then a maximum in Summer) were different from those of Belgium and other countries of Northern and Western Europe, where a maximum in mortality occurred in Winter (Franzini, 1842). These old data were brought to

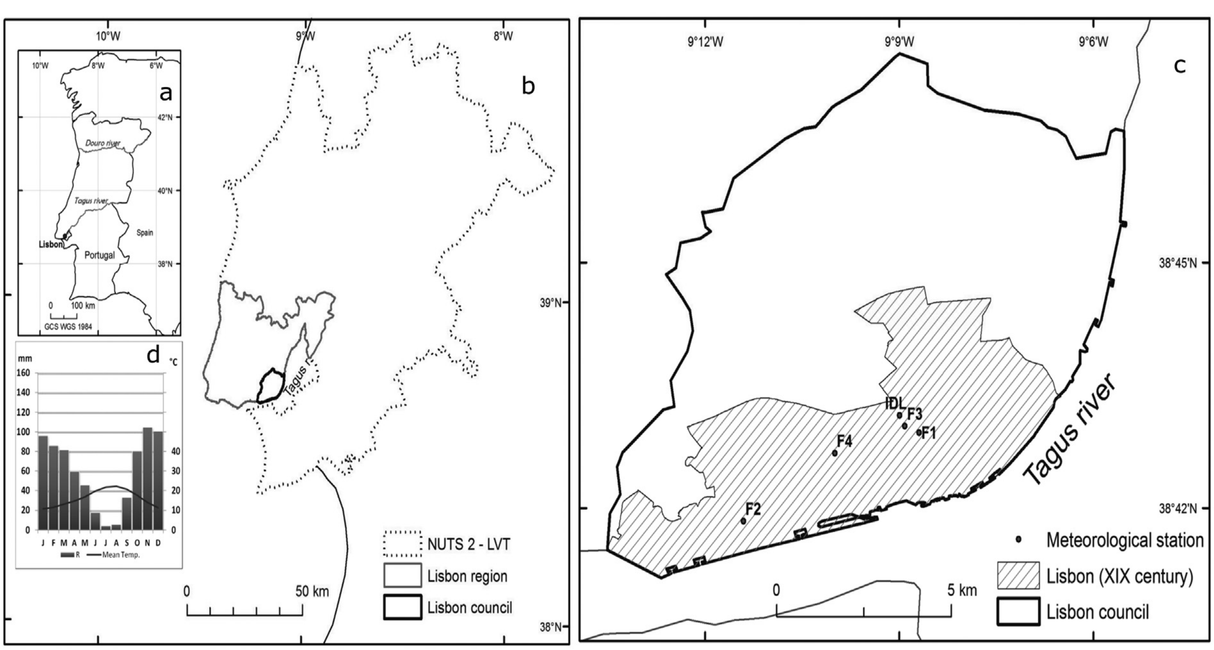

Fig. 1. Lisbon: Mortality data spatial units (a and b), meteorological station sites (c) and monthly temperature and precipitation chart (d). See also text and Table 2.