



## Heat-related mortality in Portugal amplified during the COVID-19 pandemic

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The warmest July ever in Portugal was observed during 2020, leading to the highest number of total deaths in July months (10430) since consistent records became available in 2009. This record summed up to the very high death toll throughout the year, characterized by the COVID-19 pandemic. As a combined result of these factors, cumulated deaths during 2020 are also the largest in the records available since 2009 (123753), corresponding to an excess of ~12000 deaths (~11% above the baseline). COVID-19 was responsible for the largest fraction of anomalous mortality during the spring months (62% of the excess during March-May) and from autumn onwards (85% of the excess during October-December). However, during the warmer season, the direct impact of the pandemic decreased substantially (as in the rest of Europe) and other causes were the main trigger for the observed excessive mortality (~3500 versus 553 COVID-19 deaths). Prolonged hot spells, occurring between June 21 and August 7, triggered persistent mortality anomalies in the upper tertile (>310 deaths/day) reaching its peak in mid-July (+45% deaths/day). Two other shorter hot spells occurring outside summer months (May and September) also appear to have contributed to significant mortality anomalies.

July 2020 registered an overall temperature anomaly of +2.6°C over continental Portugal, and a cumulated anomaly of +127°C. The lethality rate associated to these cumulated anomalies (+14 deaths per cumulated °C) was higher than that observed in recent relevant heat-related mortality episodes, even those with higher absolute temperature anomalies, such as in 2013 and 2018. Rates comparable to those observed in 2020 in Portugal are only found far back in tragic heatwaves like those experienced in June 1981 or August 2003. In fact, the 2003 European heatwaves triggered significant changes in public health policies, in order to minimize the mortality burden associated to hot spells, which resulted in lower lethality rates, until 2020. These results are further supported by a statistical model developed to estimate expected deaths due to cold/heat (calibrated for 2009-2019:  $r=0.84$ ;  $ME=7\%$ ), estimating an amplification of at least 50% in heat-related deaths during 2020 compared to pre-pandemic years. We argue that the significant decrease observed in emergency admissions (ER) and disruption in health-care since the start of the pandemic helps explaining this amplification factor. A ~2/3 decrease in total ERs was observed at the peak of the COVID-19 crisis, never returning to normal pre-pandemic levels. Furthermore, in average cases classified as emergent and very urgent in triage remained below 80% of previous

reference levels throughout the 2020 summer, particularly the latter.

The authors would like to acknowledge the financial support FCT through project UIDB/50019/2020 - IDL.