Temperature Extremes and Human Health in Cyprus: Investigating the Impact of Heat and Cold Waves

Fragkeskos Kekkou[1], Theo Economou[1,2], Georgia Lazoglou[1] and Christina Anagnostopoulou[3]

1. *Climate and Atmosphere Research Center (CARE-C), The Cyprus Institute, Aglantzia, Cyprus*
2. *Department of Mathematics and Statistics, University of Exeter, Exeter, UK*
3. *Department of Meteorology and Climatology, School of Geology, Faculty of Sciences, Aristotle University of Thessaloniki, Thessaloniki, Greece*

ABSTRACT

In Mediterranean regions like Cyprus, extreme temperatures due to climate change pose significant health risks. This study analyzed extreme heatwave and coldwave events from 2000 to 2019 using ERA5-Land reanalysis data. Employing statistical machine learning methods such as Distributed Lag Models (DLMs) and Generalized Additive Models (GAMs), mortality and hospitalization risks for major health concerns in Cyprus, along with attributable deaths and hospital admissions associated with temperature fluctuations and extreme events over two seasons, were estimated. Findings confirm that cold-related mortality exceeds heat-related mortality in absolute terms. However, during heatwave days, the rate of increase in attributable deaths is five times higher compared to typical days in the warm season, whereas for cold days it is about twice as high as on non-cold days.

CONTACT INFO

Fragkeskos Kekkou

(PhD Student - Graduate Research Fellow)

f.kekkou@cyi.ac.cy

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1 INTRODUCTION

- The Mediterranean, especially the Eastern region, is a climate change hotspot, experiencing temperatures rising nearly twice the global average, resulting in significant warming and drying trends. [1,2]
- Both extreme heat and cold disrupt physiological functions, exacerbating chronic conditions and leading to severe illnesses or death [3]. Cold weather often has a greater impact on health than heat, especially in warmer regions like Cyprus [4].
- Despite these risks, few studies have examined the health impacts of temperature extreme events in Cyprus. This study addresses this gap by analyzing the effects of both heatwaves and cold waves on mortality and hospitalizations from 2004 to 2019.

This study uses advanced statistical methods to quantify the significant health risks posed by temperature extremes in Cyprus, highlighting the urgent need for targeted public health interventions.

2 METHODS AND MATERIALS

- **Hot Days Definition:** Days where both Tmax and Tmin exceed the 95th percentile for the warm season (May-October)
- **Cold Days Definition:** Days where both Tmax and Tmin fall below the 5th percentile for the cold season (November-April)
- **Statistical Analysis**: Utilized Generalized Additive Models (GAMs) with Distributed Lag Non-Linear Models (DLNMs) to estimate relative and cumulative risk (RR & CR) plots and attributable fractions (AF) of mortality and hospitalizations.
- **Cumulative Risk (CR):** The sum of deaths/hospitalizations Relative Risk across all lag days for each temperature exposure. **Attributable Fraction (AF)**: Quantifies the proportion of deaths/hospitalizations directly linked to non-optimal temperatures, helping to assess the health burden of extreme temperature events.

Temperature Data

Source: ERA5-Land Reanalysis Dataset
Data: Maximum & Minimum Temp
Period: 1979 – 2019
Spatial Resolution: 0.1°x0.1°

Mortality Data

Source: Cyprus Ministry of Health
Data: Daily deaths (ICD-10 code) Circulatory and Respiratory related
Period: 2004 - 2019

Hospitalization Data

Source: Statistical Service of Cyprus
Data: Daily admissions related to circulatory and respiratory diseases
Period: 2004 - 2019

3 RESULTS

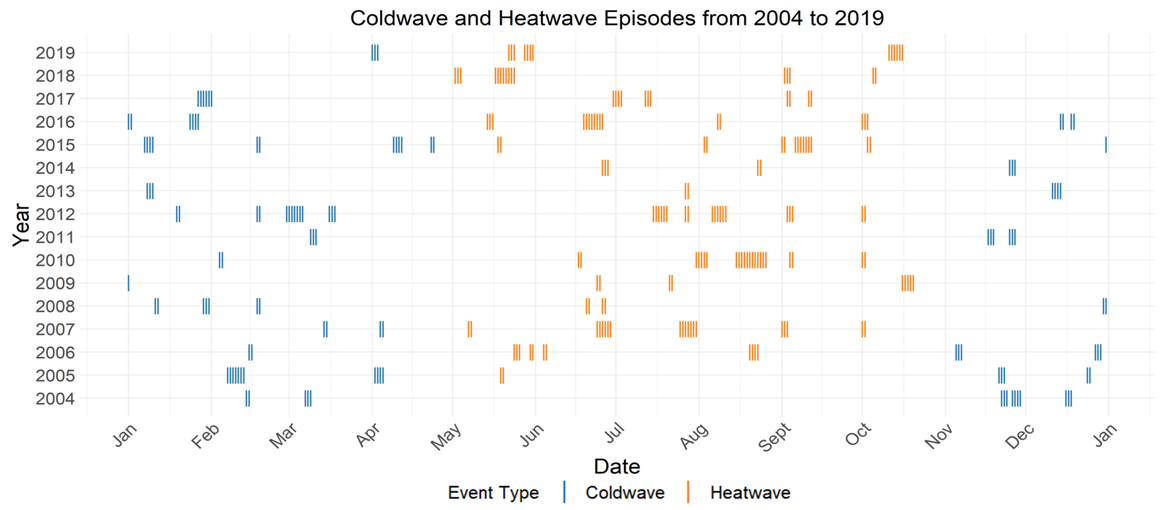

Figure 1: *Episodes of extreme temperatures in Cyprus (2004–2019). Each symbol represents a day: orange for hot days - heatwaves (warm season) and blue for cold days - coldwaves (cold season).*

Heatwaves and Coldwaves: Extreme Temperatures Episodes with more than 2 consecutive days:

Cyprus experienced 48 heatwave episodes in the warm season, lasting up to 12 consecutive days. Similarly, 39 coldwave episodes, lasting up to 7 consecutive days in the cold season.

Cause-specific: *Circulatory and respiratory diseases were most sensitive to temperature extremes, especially during cold periods. Diabetes-related hospitalizations increased slightly after heatwaves, while cancer showed weaker associations overall.*

Mortality:

- Mortality risk increased significantly at both high and low temperatures. Warm season: rose from 7.5% on typical days to 14.3% during heatwaves. Cold season: colder temperatures led to a prolonged but smaller peak of 4.2%. Cumulative risks showed a U-shape in the warm season and steady rise as temperatures fall in the cold season.

Hospitalizations:

- Hospitalization risks remained generally lower than mortality risks across both warm and cold seasons. Cumulative risks increased at lower temperatures in both seasons, with notably higher hospitalization risks during cold periods.

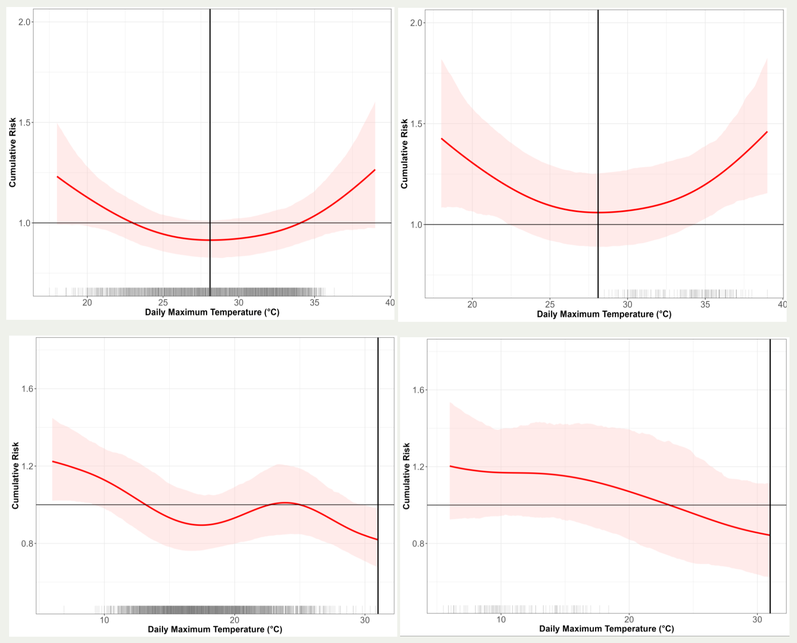

Figure 2*: Cumulative relative risk estimates with uncertainty and optimal temperature (indicated by the black vertical line) for maximum temperature, shown for cardiovascular and respiratory mortality during warm season (top) and hospitalizations (bottom) during cold season*

Table 2: *AF for wave and typical days across both seasons for Tmin and Tmax, with 95% CI.*

Forward Attributable Fraction			
May – October		November - April	
Typical Days	Heatwave Days	Typical Days	Coldwave Days
Mortality $\overline{AF}$			
0.036 [0.01–0.06]	**0.188** [0.11–0.26]	**0.236** [0.16–0.38]	**0.508** [0.42–0.61]
Hospitalizations $\overline{AF}$			
0.142 [0.09–0.19]	**0.167** [0.10–0.23]	**0.149** [0.04–0.32]	**0.167** [0.06–0.35]

Attributable Deaths

- Coldwave days are linked to up to ~50% of total deaths due to cardiovascular and respiratory issues, **significantly higher** than the ~ 19% attributable to heatwave days.
- AF is nearly 5.2 times higher on heatwave days and almost 2.2 times higher on coldwave days compared to typical days.

Attributable Hospitalizations

- Hospitalizations slightly increased during both coldwave and heatwave periods compared to typical days.

4 CONCLUSIONS

This study highlights the significant health impacts of extreme temperatures in Cyprus

- We observed an increase in hot days and a decrease in cold days over the study period.
- Mortality risks peaks at extremes, with extreme cold leading to significantly higher deaths and hospitalizations.
- While cold temperatures pose the most severe health risks overall, extreme heat increases mortality rates more rapidly than cold.

These findings underscore the need for public health strategies that address the risks posed by both high and low temperatures, especially in the context of ongoing climate change.

5 REFERENCES

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