The effect of extreme cold temperatures on the risk of death in the two major cities of Portugal

Antunes L [1,2], Silva S [2], Marques J [1], Nunes B [2,3], Antunes S [1]

[1] Department of Climate and Climatic Changes, Portuguese Institute for the Sea and the Atmosphere, Portugal
[2] Department of Epidemiology, National Health Institute Doutor Ricardo Jorge, Portugal
3 National School of Public Health, New University of Lisbon, Portugal

BACKGROUND

It is well known that meteorological conditions influence the comfort and human health [1]. Southern countries show the highest mortality rates during winter [2,3,4], including Portugal, but the effects of extreme cold temperatures in Portugal have never been estimated. The objective of this study was to estimate the effect of extreme cold temperatures on the risk of death in Lisbon and Oporto, aiming the production of scientific evidence for the development of a real-time health warning system.

METHODS

Poisson regression models combined with distributed lag non-linear models (DLNM) were applied to assess the association between minimum temperature and all-causes[a] and circulatory[b] plus respiratory[c] system diseases (C&R) mortality from 1992 to 2012, stratified by age, for the period from November to March. The analysis was adjusted for over dispersion and population size and for the confounding effect of influenza epidemics. The best fitted model for each group was chosen by Akaike's criterion for quasi-poisson models (QAIC) [5]. Different functions to describe each relationship were tested: Exposure-response relation (Minimum temperature-mortality: Linear; Influenza[d] -Mortality: NS[e] with 3-5 df[f]); Lag patterns (NS[e] with 3-5 df[f], 2nd- 4th order polynomials and Simple Moving Average); Trend (NS[e] with 4 df[f] and 3rd order polynomial) and Seasonality (NS[e] with 4-6 df[f] and 2nd order polynomial). Relative Risk (RR) of death from extreme cold temperatures in the 1st percentile was compared with the 99th percentile of minimum temperatures for each city. Summaries, inference and graphs were obtained using "DLMN" R package [6]. All statistical analysis and modeling were performed in R version 3.1.1 [7].

[a] ICD-10 codes A00-Y98; [b] ICD-10 codes I00-I99; [c] ICD-10 codes J00-J99; [d] ILI Incidence Rate per 10^5 inhabitants; [e] Natural Cubic B-Spline; [f] Degrees of freedom

RESULTS

- The immediate effect of extreme cold temperatures (lag 0) was not statistically significant for both outcomes (all-causes and C&R mortality), in the total population and in the age group of 65+ in both cities;
- After 1-2 days significant increased risk of death appeares and increased until 6-7 days where it reaches its maximum effect (Figure 1);
- Until 20-23 days the effect of extreme cold temperatures decreases but was still significant in Oporto.
- In Lisbon significant effects persist for longer, lasting for 27-28 days.
- After 29 to 31 days, cold temperatures showed a protective effect in both outcomes, for the total population and the elderly, in both cities.
- Only in Lisbon, with exception for C&R mortality in the total population, at lag 31 this protective effect was found to be significant.
- For all-causes mortality the overall effect or the cumulative effect of extreme cold temperatures over 31 days was higher in Lisbon in comparison with Oporto (Table 1). However, the estimated effects between Lisbon and Oporto were similar.
- The overall effect of extreme cold temperatures on C&R mortality was also higher in Lisbon than in Oporto. However, for this cause of death the effect of cold is evidently higher in Lisbon.
- In fact, the highest risk of death from cold was estimated for C&R mortality in the elder population living in Lisbon.

Table 1 – Estimated reltive risk from extreme cold effects (1st vs 99th percentile of minimum temperatures) and maximum lag specific increase on the risk of death for each outcome (all-causes and C&R mortality) and city (Lisbon and Oporto) for the total population and in the age group 65+.

	Extreme cold effects	Maximum lag-specific increase	
Lisbon	**RR (95% CI)**	**Lag**	**% (95% CI)**
All-causes	1.66 (1.57 – 1.76)	6	4.34 (3.80 – 4.89)
C&R	1.96 (1.81 – 2.13)	6	5.64 (4.88 – 6.41)
All-causes 65+	1.81 (1.70 – 1.94)	6	5.17 (4.56 – 5.79)
C&R 65+	2.05 (1.89 – 2.23)	6	6.08 (5.27 – 6.89)
Oporto	**RR (95% CI)**	**Lag**	**% (95% CI)**
All-causes	1.57 (1.48 – 1.67)	6	3.82 (3.25 – 4.40)
C&R	1.76 (1.61 – 1.93)	7	4.37 (3.57 – 5.18)
All-causes 65+	1.71 (1.60 – 1.84)	6	4.31 (3.70 – 4.93)
C&R 65+	1.83 (1.67 – 2.01)	6	4.72 (3.88 – 5.57)

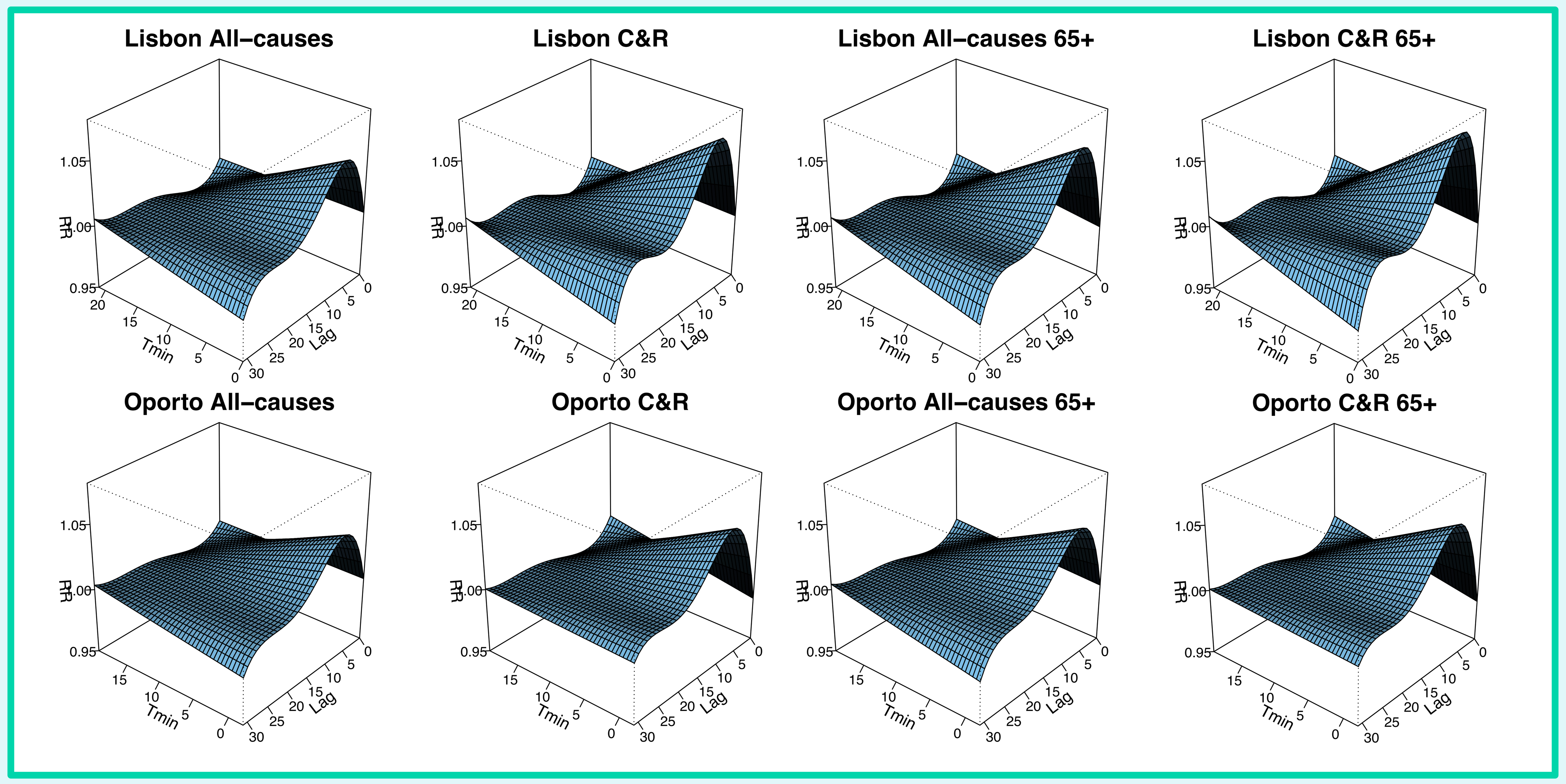

Figure 1 – Exposure-response surface for the relation between minimum temperature and mortality (all-causes and C&R) for the general population and for the age group of 65+.

DISCUSSION AND CONCLUSIONS

Different effects of cold temperatures in these two regions suggest that measures can be taken to reduce the impact from cold, especially in Lisbon. However, extreme cold temperatures have impact in both regions and preventive measures are needed. The first step should be predicting these events to allow mitigation of its impacts through a contingency plan. We believe that this work is the first step for the social, governmental and policy awareness, on the need of reducing the impacts of extreme cold temperatures in Portugal and the basis for the development of an early warning system of cold snaps with severe impact on the elderly population.

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