Ricardo Almendra[1], Paula Santana[1*], João Vasconcelos[2], Elisabete Freire[3]
[1] CEGOT, Departamento de Geografia, Universidade de Coimbra; Instituto de Estudos Geográficos, Largo da Porta Férrea, Faculdade de Letras da Universidade de Coimbra, 3004-530 Coimbra — Portugal; e-mail: ricardoalmendra85@gmail.com
*** Corresponding author**, e-mail: paulasantana.coimbra@gmail.com
[2]GITUR/ESTM — Instituto Politécnico de Leiria, Santuário de Nossa Senhora dos Remédios, 2520-641 Peniche — Portugal
[3]CIAUD, Universidade de Lisboa; Rua Sá Nogueira, Pólo Universitário do Alto da Ajuda, 1349-055 Lisboa– Portugal

SEASONAL MORTALITY PATTERNS DUE TO DISEASES OF THE CIRCULATORY SYSTEM IN PORTUGAL

ABSTRACT. Exposure to cold weather has negative consequences on human health. Studies have been showing that the seasonality of mortality has an evident peak during winter months in European countries. However, the highest increases in mortality are registered in countries with mild winters. According to several studies winter deaths seem to be associated with low socioeconomic conditions. The main aims of this study are to identify the trends of mortality due to diseases of the circulatory system and excess winter deaths in Portugal and to assess the geographical pattern of seasonal mortality. In the 20 years under analyses, mortality due to diseases of the circulatory system increased 38% during winter months when compared to the non-winter period. Important regional disparities were found, the Excess Winter Death index ranged from 21% to 48%, the central regions tend to have better results. Our results indicate that although circulatory mortality is significantly decreasing in Portugal, the vulnerability to seasonal cold weather remains as an important public health issue. These findings suggest that the exposure to cold weather is an important determinant of cardiovascular diseases that is still neglected in Portugal.

KEY WORDS: diseases of the circulatory system; seasonal mortality; excess winter deaths; Portugal

INTRODUCTION

In Portugal, mortality due to diseases of the circulatory system is decreasing at an important pace since the last decades in result of significant improvements in healthcare and life conditions [Santana, 2014]. However, still remains as one of the main causes of morbidity and death.

In most European countries, mortality has an important seasonal variation, characterized by a peak during the winter months and a decrease in rest of the year [Healy, 2003], this pattern is even more significant when the analysis is focus on diseases of the circulatory or respiratory system [Eurowinter Group, 1997; Rau, 2006]. Cardiovascular mortality is strongly related with weather conditions, being the cause of death with higher increases due to temperature variations. The increases are recorded both during high and low temperatures, although the number of Excess Winter Deaths (EWD) is higher than the heat related mortality.

Exposure to lower temperatures has important biological effects. Within certain thresholds, the human body can maintain thermal comfort through appropriate thermoregulatory responses so that physical and mental activities can be pursued without any detriment to health [Xu et al., 2012]. However, when the human body is exposed to temperatures below the biological optimum the circulatory system becomes under stress, causing an increase in blood pressure, blood viscosity and fibrinogen concentration [Keatinge, 2002; Maheswaran et al., 2004; Stocks et al., 2004].

Healy [2003], mentions the "paradox of excess winter mortality", as the higher mortality rates are generally found countries with milder winter where, all else equal, there should be less potential for cold strain and cold related mortality. This pattern suggest that excess winter mortality should not be seen as an environmental inevitability [Davie et al., 2007]. Besides the meteorological conditions, several factors influence the vulnerability to cold weather: physical activity, age, gender and accompanying exercise [Stocks et al., 2004], as well as the ability to avoid cold exposure in indoor and outdoor environments [Mäkinen et al., 2006; Rau, 2006; Vasconcelos et al., 2011].

Thus, excess winter mortality should be seen as an important public health issue that demands proper measures and policies [Monteiro et al., 2012]. In some countries, such as Scotland and United Kingdom, EWD are seen as a public health priority [Gemmell, 2001], and specific actions to mitigate it are supported. Reduction of fuel poverty, monitoring and subsidizing the vulnerable homes are some examples of the national initiatives developed at a national level.

Unlike other countries, in Portugal seasonal mortality and morbidity is underrated as a severe threat to public health, there is no systematic quantification or measures to tackle the vulnerability to cold weather.

This paper aims to: i) characterize the evolution of overall and seasonal mortality due to diseases of the circulatory system in Portugal (since 1990 until 2009); and ii) identify the geographical pattern of excess winter mortality (in the ten years period 2000-09).

DATA AND METHODS

This study uses Standardized Deaths Rates due to diseases of circulatory system, obtained from the European Health for All database (http://data.euro.who.int/hfadb/), and monthly deaths through diseases of the circulatory system (ICD 10: I00-I99), obtained from Statistics Portugal (www.ine.pt). Data was collected from 1990 until 2009. Deaths by month were standardized to 30-days with an adjustment for leap years, and analysed by NUT III.

The number of EWD and the EWD index were calculated according to Johnson and Griffi [2003] in order to quantify the winter mortality burden.

The number of EWD is calculated by comparing the number of deaths in winter months (December to March) with the average number in non-winter months (the previous August to November and the following April to July):

$$EWD = \text{Winter deaths} - \frac{\text{Non-Winter death}}{2}.$$

Once the number of EWD was found, the EWD rate was calculated in Portugal (from 1990 to 2009) and each NUT III (ten years period 2000-09) using the resident population available in Statistics Portugal.

The seasonal impact of winter was assessed through the EWD Index. It indicates whether there are higher than expected deaths in the winter compared to the rest of the year:

$$EWD\,\text{index} = \left(2\frac{\text{Winter deaths}}{\text{Non-winter deaths}} - 1\right)100.$$

And their 95% confidence intervals:

$$\text{CI} = 2e^{\left[LN\left(\frac{\frac{\text{Winter deaths}}{\text{Non-Winter deaths}} \pm}{\pm 1{,}96\sqrt{\frac{1}{\text{Winterdeaths}} + \frac{1}{\text{Non-Winter deaths}}}}\right)\right]} - 1.$$

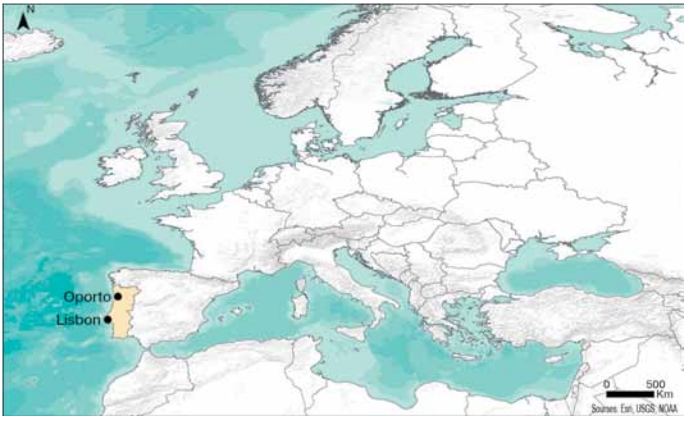


Fig. 1. Location of the study area. Portugal.

The joinpoint regression model was used to identify significant changes cardiovascular mortality, EWD rate and EWD index. This method detects statistically significant changes in trend, and the annual percent of change is computed by each of those trends by means of generalised linear models assuming a Poisson distribution [Fernandez et al., 2001]. The joinpoint analyses were performed using the "Joinpoint" software from the US National Cancer Institute (available at http://surveillance.cancer.gov/joinpoint/).

RESULTS

Portugal is located by the Atlantic Ocean (Fig. 1), according to Köppene and Geiger the southern regions are classified as a hot-summer Mediterranean climate (Csa) and the northern as warm-summer Mediterranean climate (Csb), both with mild winters [Vasconcelos et al., 2011].

TREND ANALYSIS

Since 1990, a decline in the standardized death rate due to diseases of the circulatory system has been observed. Two points, where the rate changes significantly, were found and three periods with significant decreases ($p < 0.05$) were identified: 1991-03; 2003-06; 2006-09.The second period (2003-06) had the higher decreasing rate (annual percent change of 7.95%) (Fig. 2).

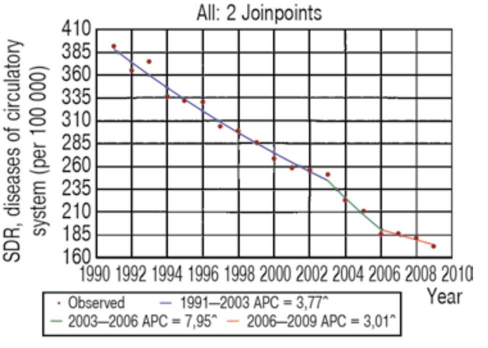


Fig. 2. Trends in Standardized Death Rates due to diseases of circulatory system, all ages, per 100 000 inhabitants.

By analyzing the monthly distribution of the number of deaths due to diseases of the circulatory system an important seasonal pattern was identified. The winter months (from December to March) have the highest number of deaths. January is the month with higher proportion of deaths (11.5%) while September had the lowest 6.5% (Fig. 3).

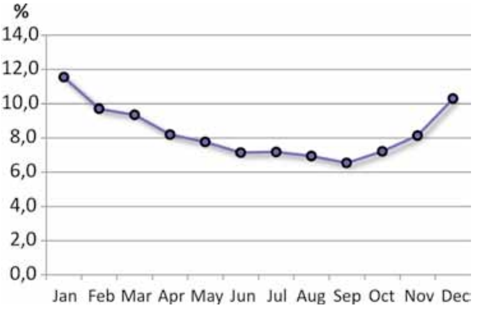
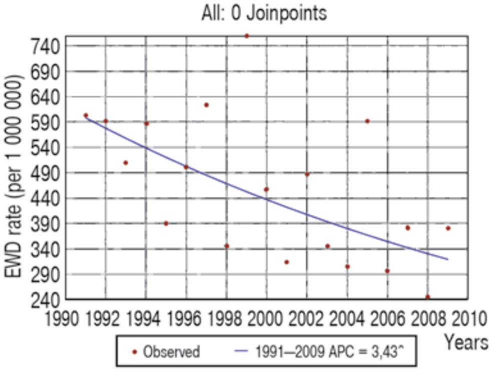
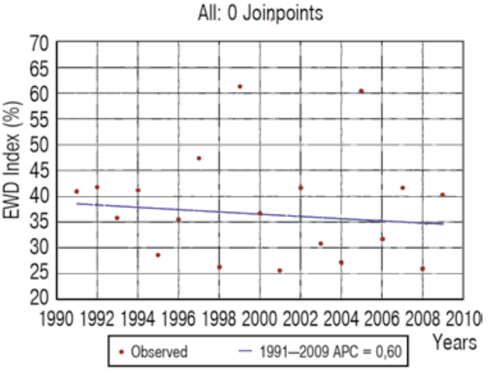


Fig. 3. Monthly distribution of deaths due to diseases of circulatory system (%) (1991–2009)



A



B

Fig. 4. Trends of Excess Winter Death rate (A) and index (B) due to diseases of circulatory system

The EWD rate is significantly decreasing since 1990 with an annual percent change of 3.43% ($p < 0.05$), however this trend is not constant due to important inter-annual variations. The highest values were recorded between 1999 with 749 per 1.000.000 inhabitants (Fig. 4 A).

The EWD index is not decreasing significantly; the evolution in the 20 years under analysis is marked by the inter-annual fluctuations. The highest value was recorded in 1999 when the number of deaths in winter months was 61.3% higher than the number of death recorded in the rest of the year (Fig. 4 B).

GEOGRAPHICAL PATTERN

Winter mortality increases were recorded throughout the country, although, the seasonal burden varied remarkably across regions. The EWD rate through circulatory diseases varied from 249 to 742 deaths per million inhabitants, while the country average is 378 per million inhabitants, the worst results were in the inland and southern regions, while the best were recorded at the coastal areas (Fig. 5).

The EWD index country average is 40%, but important regional disparities were found (ranging from 21% to 48%), the central regions of the country tend to have better results, even though a clear pattern was not identified. During winter-moths the number of deaths was 40% higher than in non-winter months, two regions had significantly lower EWM index than the Portuguese average and any region had significantly higher values.

DISCUSSION

Joinpoint analyses allowed the identification of significant decreasing trends, between 1990 and 2009, in the standardized death rates due to diseases of the circulatory system and EWD rate. Despite these trends, the EWD index is not decreasing significantly. The geographical pattern shows important regional disparities, the EWD rate tend to be higher in the regions near the border and the EWD index is lower in the central regions, although is difficult to identify a clear pattern.

The improvements in healthcare and living conditions can explain the significant decrease in the standardized death rate due to diseases of the circulatory system. These diseases have been the major cause of death in Europe for some decades and therefore several European countries have undertaken health policies to control this public health burden [Levi et al., 2002]. The gap between Portugal and the other European countries is diminishing but still has higher mortality rate than the EU' 15 average [Santana, 2014].

There is an uneven distribution of mortality throughout the year in Portugal, the mortality seasonal pattern shows a clear cluster during winter months, this trend is usually found in several European countries [Rau, 2006], and

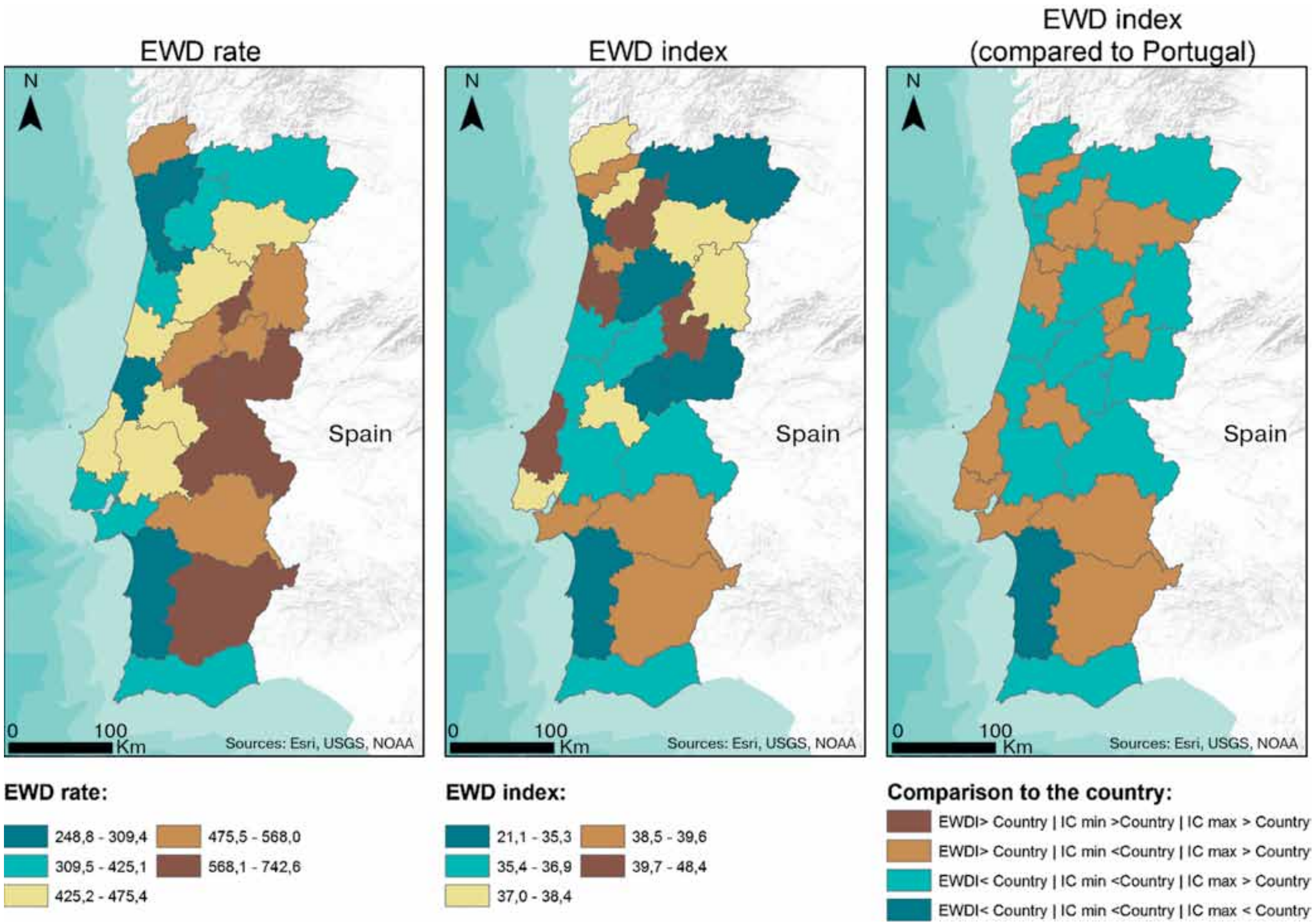


Fig. 5. Excess Winter Death rate, index and comparison with country average

Portugal is often described as the European country with higher vulnerability to cold weather [Healy, 2003; Almendra, Freira, Vasconcelos, 2012; Eurowinter Group, 1997].

The excess winter deaths are associated with several environmental factors such as exposure to cold weather [Burkart et al., 2011; Vasconcelos et al., 2013], but biological (e.g., age and sex) [Goodwin, 2000], socio-economic (e.g., deprivation, housing conditions) [Maheswaran et al., 2004; Healy, 2003; Vasconcelos et al., 2011] and behavioural (e.g., use of adequate clothing, avoiding the exposure to cold weather) [Aylin et al., 2001; Mäkinen et al., 2006; Rau, 2006] factors also play an important role in the vulnerability to cold weather.

Inter-annual variations are usually explained by winter characteristics (eg. temperature, extend) and influenza incidence rates, these events can contribute to abnormal values of EWD rate and index and explain outliers.

Different regional patterns were found between the EWD rate and index, in order to understand them is important to acknowledge that temperature and thermal comfort are two very different parameters, being the last more important to explain the winter mortality increase. This disparity between patterns was also found among regions in England [Office for National Statistics, 2013].

The EWD rate geography is consistent with the overall mortality pattern, and so is strongly influenced by biological and life style determinants such as age, obesity, sex, smoking, alcohol consumption, sedentary habits, stress, diet, among others [Dahlöf, 2010].

The EWD index geographical pattern is more difficult to explain, neither age, deprivation nor the overall mortality due to diseases of the circulatory system can fully explain it. Further studies focus on behaviour conditions are needed in order to understand this pattern.

The EWD rate compares the number of deaths in winter months with the average number of deaths occurring in non-winter months. This measure is important to quantify the burden of excess winter deaths, but fails when comparisons between sexes, age groups and regions are needed once is strongly related with the overall mortality due to diseases of the circulatory system and their determinants (e.g., Age). The EWD index allows comparisons between different geographies or age groups once it is calculated as the number of excess winter deaths divided by the average non-winter deaths [Johnson, Griffi, 2003].

With the improvements in socioeconomic and healthcare conditions it would be expected to assist a significant decrease in both EWD rate and index. Although the decreasing trend observed in the standardized death rate was followed by the EWD rate there is no significant trend in the EWD index. In England (since 1991), the EWD index does not have a significant decreasing trend either [Office for National Statistics, 2013].

CONCLUSIONS

These findings highlight that although significant efforts have been developed to reduce the impacts of cardiovascular diseases in Portugal, their effects on the disease seasonality are still far from being achieved. One possible explanation is that other epidemiology aspects of the cardiovascular diseases need to be addressed, such as the indoor environment and the reduction of cold exposure.

Nevertheless, the seasonal pattern in the mortality by circulatory system diseases is highly evident and it is still not properly addressed by health authorities in Portugal.

ACKNOWLEDGEMENTS

This Research was conducted within the framework of the "Geography of health status — An application of a Population Health Index in the last 20 Years – GeoHealthS" and CLIMAHABS projects funded by FCT (Fundação para a Ciência e Tecnologia).

REFERENCES

1. Almendra, R., Freira, E., Vasconcelos, J. (2012) Excess winter cardiovascular diseases throughout Europe. Eur. J. Epidemiol, 27. Suppl. 1, 149.
2. Aylin, P., Morris, S., Wakefield, J., Grossinho, a, Jarup, L., Elliott, P. (2001) Temperature, housing, deprivation and their relationship to excess winter mortality in Great Britain, 1986–1996. Int. J. Epidemiol., 30, 1100–8.
3. Burkart, K., Khan, M.H., Krämer, A., Breitner, S., Schneider, A., Endlicher, W.R. (2011) Seasonal variations of all-cause and cause-specific mortality by age, gender, and socioeconomic condition in urban and rural areas of Bangladesh. Int. J. Equity Health, 10, 32.
4. Dahlöf, B. (2010) Cardiovascular disease risk factors: epidemiology and risk assessment, Am. J. Cardiol., 105, 3A–9A.
5. Davie, G.S., Baker, M.G., Hales, S., Carlin, J.B. (2007) Trends and determinants of excess winter mortality in New Zealand: 1980 to 2000. BMC Public Health, 7, 263.
6. Eurowinter Group (1997) Cold exposure and winter mortality from ischaemic heart disease, cerebrovascular disease, respiratory disease, and all causes in warm and cold regions of Europe. Lancet, 349, 1341–6.
7. Fernandez, E., González, J., Borràs, J., Moreno, V., Sánchez, V., Peris, M. (2001) Recent decline in cancer mortality in Catalonia (Spain). A joinpoint regression analysis. Eur. J. Cancer 37, 2222–2228.
8. Gemmell, I. (2001) Indoor heating, house conditions, and health.J. Epidemiol. Community Health, 55, 928–9.
9. Goodwin, J. (2000) Cold stress, circulatory illness and the elderly, in: Cutting the Cost of Cold: Affordable Warmth for Healthier Homes. New York: E & FN Spon, pp. 47–60.
10. Healy, J.D. (2003) Excess winter mortality in Europe: a cross country analysis identifying key risk factors. J. Epidemiol. Community Health, 57, 784–789.
11. Johnson, H., Griffi, C. (2003) Estimating excess winter mortality in England and Wales. Health Statistics Quarterly, 20: 19–24.
12. Keatinge, W.R. (2002) Winter mortality and its causes. Int J Circumpolar Heal., 61, 292–299.
13. Levi, F., Lucchini, F., Negri, E., La Vecchia, C. (2002) Trends in mortality from cardiovascular and cerebrovascular diseases in Europe and other areas of the world. Heart, 88, 119–24.
14. Maheswaran, R., Chan, D., Fryers, P.T., McManus, C., McCabe, H. (2004) Socio-economic deprivation and excess winter mortality and emergency hospital admissions in the South Yorkshire Coalfields Health Action Zone, UK. Public Health, 118, 167–176.
15. Mäkinen, T.M., Raatikka, V.-P., Rytkönen, M., Jokelainen, J., Rintamäki, H., Ruuhela, R., Näyhä, S., Hassi, J. (2006) Factors affecting outdoor exposure in winter: population-based study; Int. J. Biometeorol., 51, 27–36.
16. Monteiro, A., Carvalho V., Góis, J. Sousa, S. (2013) Use of "Cold Spell" indices to quantify excess chronic obstructive pulmonary disease (COPD) morbidity during winter (November to March 2000–2007): case study in Porto. International Journal of Biometeorology, 57, 6, 857–870.
17. Office for National Statistics (2013) Excess Winter Mortality in England and Wales. London: Office for National Statistics, 23 p.
18. Rau, R. (2006) Seasonality in Human Mortality: A Demographic Approach; Berlin: Springer, 232 p.
19. Santana, P. (2014) A saúde dos portugueses, in: Simxes, J. (Ed.), 40 Anos de Abril Na Saúde. Coimbra: Almedina, pp. 69–92.
20. Stocks, J.M., Taylor, N.A.S., Tipton, M.J., Greenleaf, J.E. (2004) Human physiological responses to cold exposure. Space. Environ. Med., 75, 444–57.
21. Vasconcelos, J., Freire, E., Almendra, R., Silva, G.L., Santana, P. (2013) The impact of winter cold weather on acute myocardial infarctions in Portugal. Environ. Pollut. 183, 14–8.
22. Vasconcelos, J., Freire, E., Morais, J., Machado, J.R., Santana, P. (2011) The health impacts of poor housing conditions and thermal discomfort. Procedia Environ. Sci. 4, 158–164.
23. Xu, Z., Etzel, R.A., Su, H., Huang, C., Guo, Y., Tong, S. (2012) Impact of ambient temperature on children's health: a systematic review. Environ. Res., 117, 120–31.

Ricardo Almendra, Geographer, PHD student since 2012 at Coimbra University is a researcher at Centre of Studies on Geography and Spatial Planning. Participated in several Portuguese scientific projects founded Portuguese national funding agency for science, research and technology. He is currently studying the impact of socioeconomic determinants in the vulnerability to environmental conditions.

Paula Santana, PhD in Geography and Full Professor at the University of Coimbra, has been dedicated to teaching and research in health geography and sustainable urban planning, highlighting the association between aspects of context and composition and the health and welfare of the population. She taught classes in Portugal (in various courses and institutions) and abroad (United Kingdom, Spain, Finland, Brazil and Macau), coordinated various projects nationwide (funded by the Foundation for Science and Technology and Ministry of Health). She is referee of seven major international journals and scientific programs (European Science Foundation and the World Health Organization). For her contribution in the field of Health Geography, she has been awarded the title of Corresponding Member of the Geographical Society of Finland, elected Member of the Steering Committee of the Commission on Health and Development (IGU) and represents Portugal in nine international scientific programs (among others, of the World Health Organization, European Union, European Science Foundation, Medical Research Council of Glasgow). She is the author of numerous scientific publications — 13 books and more than 200 articles in national and international journals.

João Vasconcelos graduated in Geography and have a Master Course on Land Management and Environmental Planning. He has a PhD in Environment from the Faculty of Sciences and Technology of the New University of Lisbon. He has been a Lecturer at the School of Tourism and Maritime Technologies from the Polytechnic Institute of Leiria since 2006, in the field of Tourism, Geography and Environment. He is the Coordinator of the Tourism Research Group (GITUR) from Polytechnic Institute of Leiria. He is also the Executive Editor of the European Journal of Tourism and Hospitality Recreation.

Elisabete Freire, Physical Geographer, MSc in Physical and Regional Geography (Coastal Geomorphology) at the University of Lisbon, PhD (Human Bioclimatology) at the University of London, PhD (Territorial Management and Planning — Environmental Sciences) at the New University of Lisbon. She is Professor at the Faculty of Architecture, University of Lisbon and Full Member of the Research Centre on Architecture, Urbanism and Design (CIAUD).