

## Seasonal mortality patterns and regional contrasts in Portugal

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**Abstract.** The main aim of this study is to identify the geographical seasonal mortality patterns in Portugal and, for the first time, to assess the relationship between seasonal and overall mortality. Monthly data from the Portuguese mortality database (2000–2009) by major cause of death were analysed and standardized to 30 days with adjustments for leap years. The chi-square goodness-of-fit test was used to compare the observed monthly deaths with deaths that could be expected if mortality were randomly distributed throughout the year. The seasonal burden was measured using the excess winter deaths (EWD) rate and the seasonal impact of winter on mortality was assessed through the EWD Index. The regions were clustered according to the overall mortality rate and the seasonal impact: 1–low seasonality and high values of overall mortality; 2–high seasonality and high values of overall mortality; 3–low values of seasonality and low overall mortality; 4–high seasonality and low overall mortality. Significant seasonal mortality increases were found in all causes of death. There were 86,000 EWDs, mostly through circulatory and respiratory diseases. 73% of the population lives in regions with high winter vulnerability to respiratory mortality and 60% in regions with high winter vulnerability to circulatory mortality. This study reinforces the idea that vulnerability to cold weather may play an important role in the public health in Portugal. This knowledge may be used to construct a set of regulations or policies designed to implement better health planning procedures and more effective warning systems.

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## 1. Introduction

The relationship between health and environment has long been studied, and there are no doubts that exposure to extreme temperatures increases the risk of morbidity and mortality (Bhaskaran et al., 2009; Kunst et al., 1991). However, the question of how ambient temperature influences health continues to be debated.

In Europe there is an apparent paradox regarding the geographical seasonal mortality pattern, as countries with mild winters have higher Excess Winter Death (EWD) rates than those with much colder climates (Eurowinter Group, 1997; Healy, 2003; Rau, 2006). This paradox suggests that seasonal mortality may be more associated with poor protection against cold weather than with the direct influence of harsh winter weather conditions (Aylin et al., 2001; Gemmell et al., 2000; Hajat et al., 2007; Vasconcelos et al., 2013).

The uneven distribution of environmental risk factors is also the result of inequalities in other social health determinants such as income, social status, employment and education, but also non-economic aspects such as gender, age or ethnicity. Therefore, seasonal mortality results more directly from socioeconomic and behavioral factors than from low temperatures. Considering this relationship, it is believed that, at least, some of the cold-related deaths can be avoided (Davie et al., 2007; McKee, 1989; Wilkinson et al., 2004).

Portugal is often described as the most vulnerable country to winter weather conditions in Europe (Healy, 2003), however, the seasonal burden is

still overlooked and has not yet been systematically quantified or used to set any public policy. As a consequence, the influence of winter weather conditions in Portugal is generally underrated compared to the influence of summer heat.

According to Donaldson and Keatinge (1997), excess winter mortality decreased 17% from 1977 to 1994 in England; this trend is attributed to better general medical care and to the improvements in socioeconomic conditions that result in better adaptation to cold weather.

It would be expected that similar results could be found in Portugal as a consequence of the improvements experienced in the socioeconomic conditions until 2009. However, in a study analysing the trends of seasonal mortality due to diseases of the circulatory system in Portugal since 1990, Almendra et al (2015) did not find a significant reduction of excess winter mortality. In Portugal, being exposed to cold weather conditions seems to be accepted as an inevitable environmental consequence (Vasconcelos et al., 2011). Therefore, and as cold weather is still highly neglected, there are no policies to mitigate its effects nor there any systematic actions to identify the impact of cold weather upon health.

It is therefore of fundamental importance to understand the role of cold as a trigger factor for several diseases, and to assess the vulnerability to winter weather conditions in Portugal, in order to provide the necessary expertise to the stakeholders (e.g. urban planners, health and social protection authorities). The main aim of this paper is to identify the geographical seasonal mortality patterns in Portugal and to assess the relationship between seasonal and overall mortality.

## 2. Data and methods

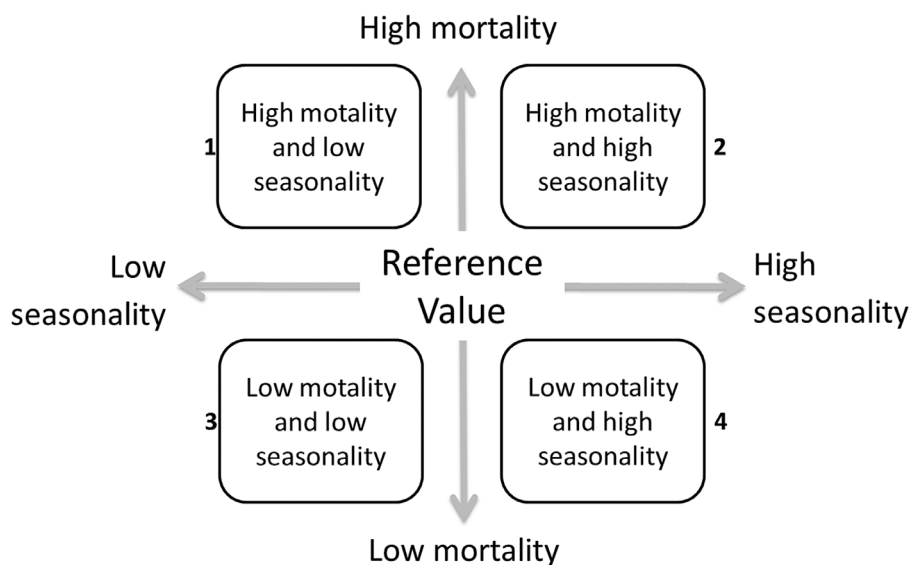
This study uses monthly data from the Portuguese mortality database from 2000 until 2009. Cause-specific mortality was clustered according to the European shortlist causes of death (Classification of Diseases 10th revision): Infectious and parasitic Diseases (A00-B99); Malignant neoplasms (C00-C97); Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (D50-D89); Endocrine, nutritional and metabolic diseases (E00-E89); Mental and behavioural disorders (F01-F99); Diseases of the nervous system and sense organs (G00-H95); Diseases of the circulatory system (I00-I99); Diseases of the respiratory system (J00-J99); Diseases of the digestive system (K00-K92); Diseases of the musculoskeletal system and connective tissue (M00-M99); Diseases of the genitourinary system (N00-N99); External causes of morbidity and mortality (V01-Y89). Deaths by month were standardized to 30-days with adjustment for leap years and analysed by region (NUT III) and country.

The chi-square goodness-of-fit test was used to compare the observed monthly deaths with deaths that could be expected if mortality were randomly distributed throughout the year (Alcorn et al., 2013). A winter/summer ratio was applied to assess the differences between summer and winter mortality: the ratio was calculated by dividing the number of winter deaths (December to March)

by the number of deaths during summer (June to September).

The number of EWD and the EWD index were calculated according to Johnson and Griffiths (2003) in order to quantify the winter mortality burden. The number of EWD was 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). The seasonal impact of winter was assessed through the EWD Index which was used to determine if the number of deaths during winter was higher than expected, when compared to the rest of the year. Thus, the EWD number is the amount of winter deaths that occurs above the average of the non-winter months of the year, while the EWD index is the proportion of the winter mortality increases.

To identify the regions where the impact of seasonal cold weather, as a trigger factor, was more pronounced, the *all-year* mortality rate (hereinafter referred to as overall mortality) and the seasonal impact were compared with the country average value. Following this process, four categories were established: 1 – high overall mortality and low seasonality; 2 – high overall mortality and high seasonality; 3 – low overall mortality and low values of seasonality; 4 – low overall mortality and high seasonality (Fig. 1). For instance, one region with higher overall mortality than the country average and with higher EWD index than the country average would be clustered in the second group of regions.



**Fig. 1.** Classification according to the overall and seasonal mortality

Source: Own elaboration

### 3. Results

#### 3.1. Seasonal mortality in Portugal

All main causes of death had significant monthly variations ( $p < 0.005$ ), and the group All causes had significant seasonal increase in every year of the decade ( $p < 0.001$ ) (Table 1).

According to the winter/summer ratio, the winter mortality increased in all causes of death, except for the external causes. The respiratory (winter/summer ratio: 1.76) and circulatory (winter/summer ratio: 1.46) diseases showed a higher seasonality having the highest differences between winter

and summer. The external causes had a slight summer increase (winter/summer ratio: 0.96), and the malignant neoplasms had a very low winter increase (winter/summer ratio: 1.05).

Attending to all causes of death, there were 85,952 EWD (8% of all mortality). The respiratory (18,116) and circulatory diseases (39,972) were the main responsible causes of death for this toll, representing about 70% of all excess winter mortality.

The mortality for all causes increased 27% in winter; again, the highest increase was among the respiratory (64%) and circulatory (37%) diseases, although the endocrine, nutritional and metabolic diseases and the nervous system diseases had winter increases over 30%.

**Table 1.** Seasonal mortality by cause (2000-09)

Cause of death (ICD 10)	Number of deaths	Chi-Square Goodness-of-Fit Test	Winter / summer	EWD	EWDI (%) (95% CI)
All causes	1,053,425	$p < 0.005$	1,32	85,952.4	27.2 (26.7; 27.7)
Certain infectious and parasitic D.	23,356	$p < 0.005$	1,07	581.6	7.8 (4.9; 10.8)
Malignant neoplasms	227,522	$p < 0.005$	1,05	3,080.3	4.2 (3.3; 5.1)
D. of the blood and blood-forming organs and certain disorders involving the immune mechanism	2,719	$p < 0.005$	1,22	160.1	19.1 (10.2; 28.9)
Endocrine, nutritional and metabolic D.	48,821	$p < 0.005$	1.41	4,950.3	34.6 (32.1; 37)
Mental and behavioural disorders	4,278	$p < 0.005$	1.29	322.9	24.9, (17.4; 33)
D. of the nervous system	23,283	$p < 0.005$	1.36	2,188.3	31.8 (28.3; 35.3)
D. of the circulatory system	372,157	$p < 0.005$	1.46	39,971.9	36.9 (36; 37.8)
D. of the respiratory system	104,295	$p < 0.005$	1.76	18,115.6	64.4 (62.4; 66.5)
D. of the digestive system	45,178	$p < 0.005$	1.21	2,533.5	18.2 (15.9; 20.5)
D. of the musculoskeletal system and connective tissue	2,513	$p < 0.005$	1.35	221.4	29.6 (19.5; 40.5)
D. of the genitourinary system	24,346	$p < 0.005$	1.32	2,148.8	29.6 (26.3; 33)
External causes of morbidity and mortality	49,427	$p < 0.005$	0.96	-	-

Source: Own elaboration based on data from the Statistics Portugal

### 3.2. Regional patterns of mortality due to diseases of the circulatory and respiratory systems and all causes

Regional mortality patterns can be identified in Portugal, both in mortality by all causes and in mortality due to diseases of the circulatory and respiratory systems; inland regions tend to have higher overall mortality rates than regions near the coast line (Fig. 2).

### 3.3. Regional patterns of excess winter mortality

Winter mortality increases were recorded throughout the country, however, the seasonal burden varied remarkably across regions and by cause of death.

The EWD rate through circulatory diseases varied from 248 to 742 deaths per million inhabitants, the highest results were in the inland and southern regions, while the lowest were recorded in the coastal areas. The winter burden due to respiratory diseases ranged from 122 to 399 deaths per million inhabitants, the northern and inland regions tended to have higher EWD rates (Fig. 3).

The EWD index due to diseases of the respiratory system varied from 42% to 91%, the worst results were registered in the North and inland regions. Regarding the circulatory diseases, the EWD index ranged from 21% to 48%, the regions in the central part of the country tended to have lower results, even though a clear pattern was not identified (Fig. 4).

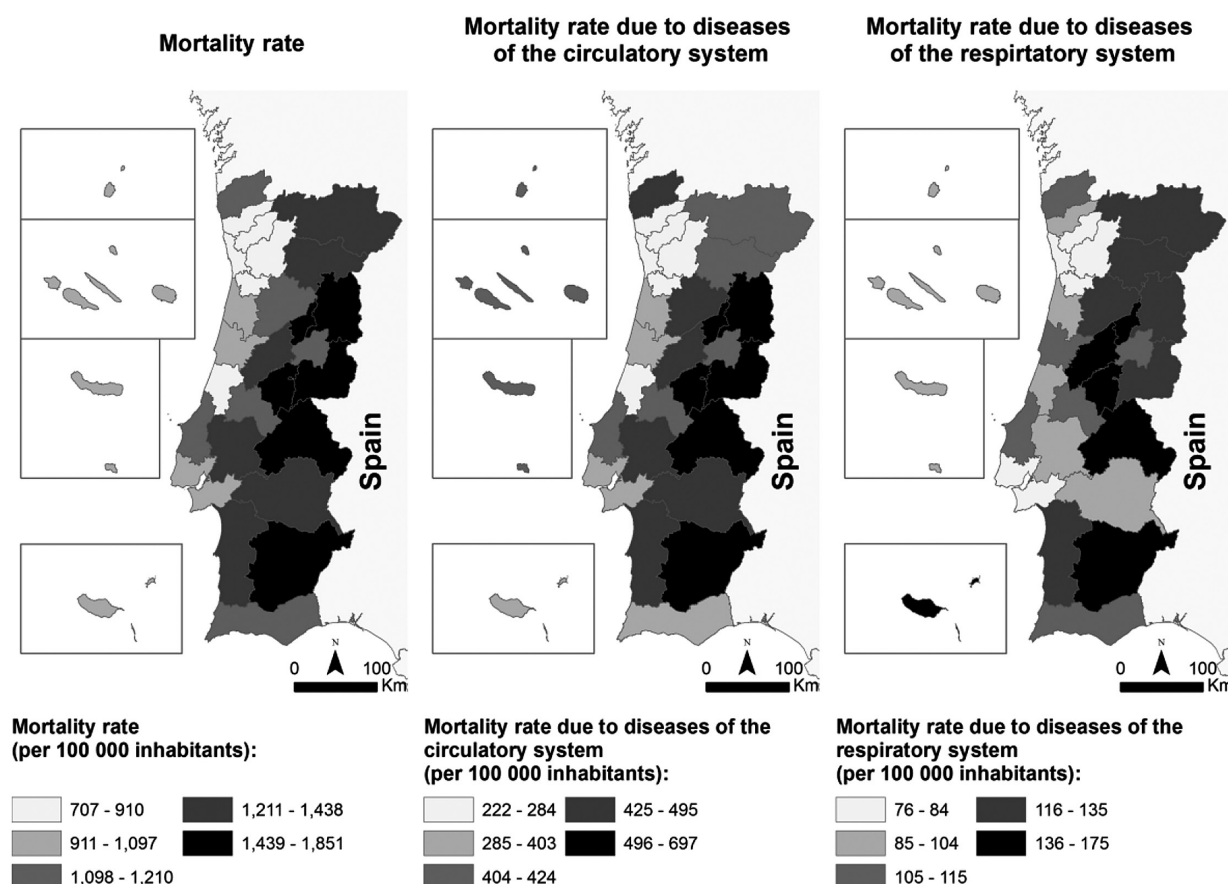
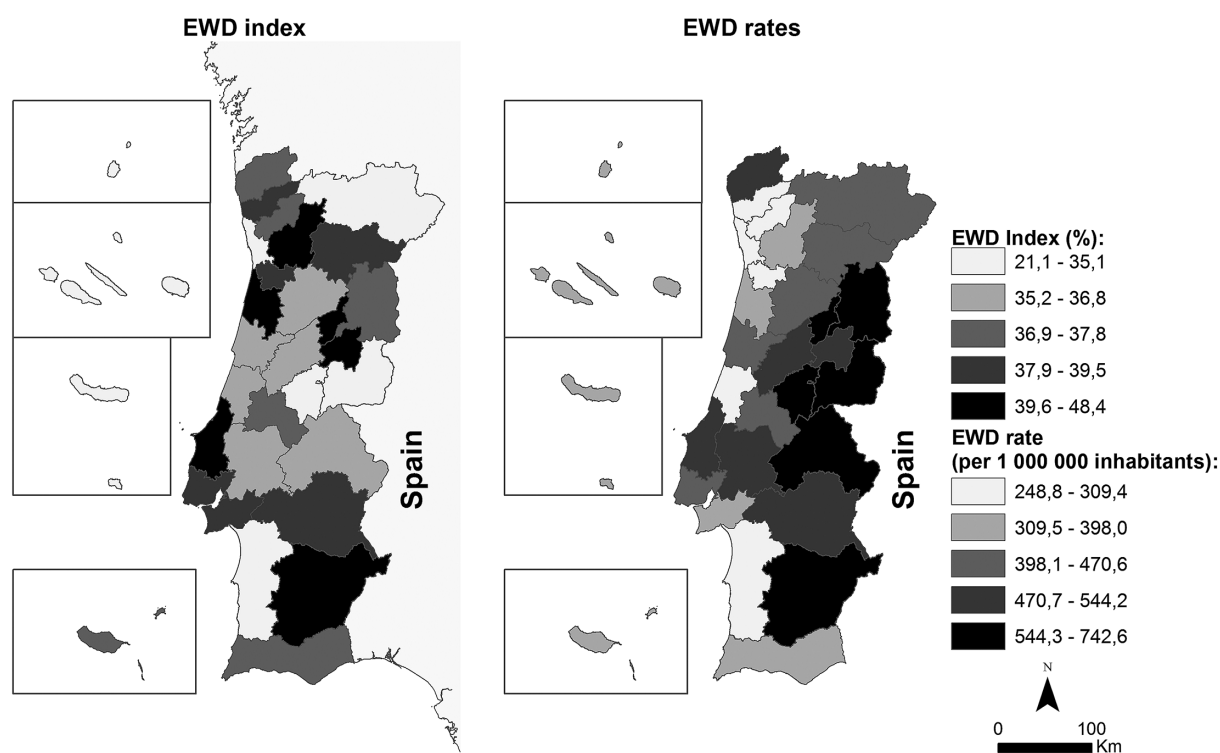
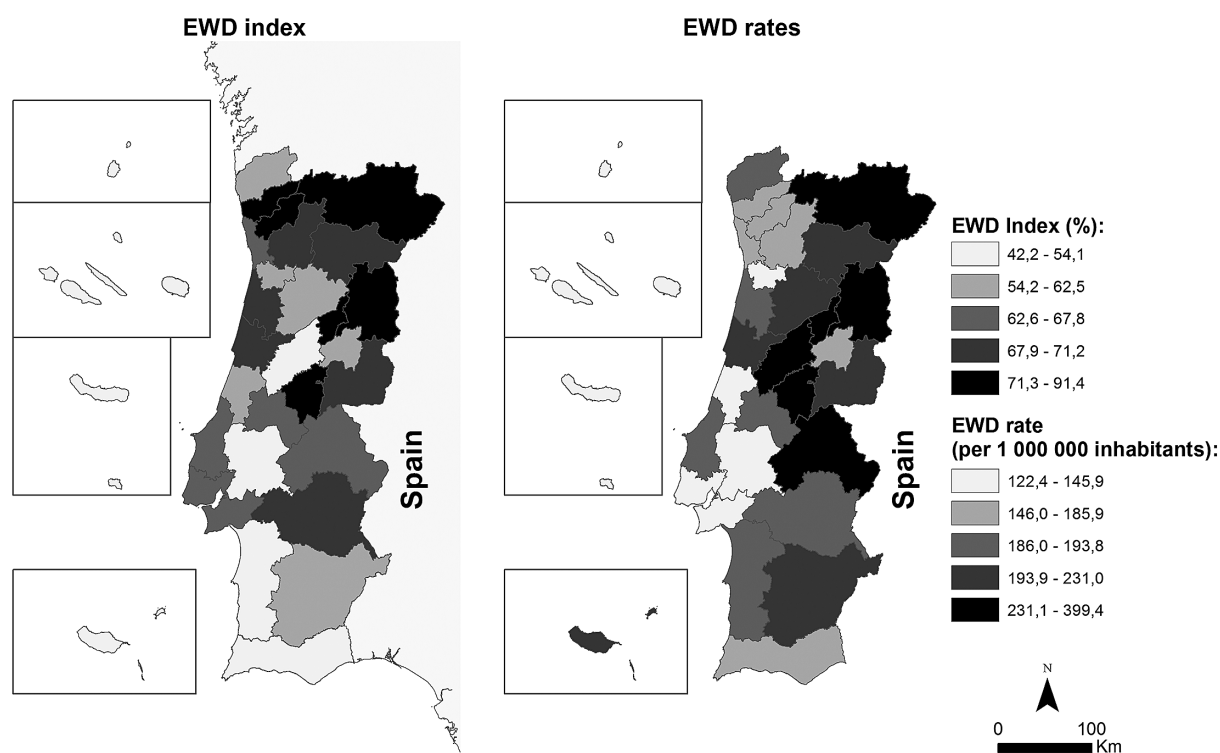


Fig. 2. Mortality rates due to diseases of the circulatory and respiratory systems and all causes

Source: Own elaboration based on data from the Statistics Portugal



**Fig. 3.** Diseases of the circulatory system  
*Source:* Own elaboration based on data from the Statistics Portugal

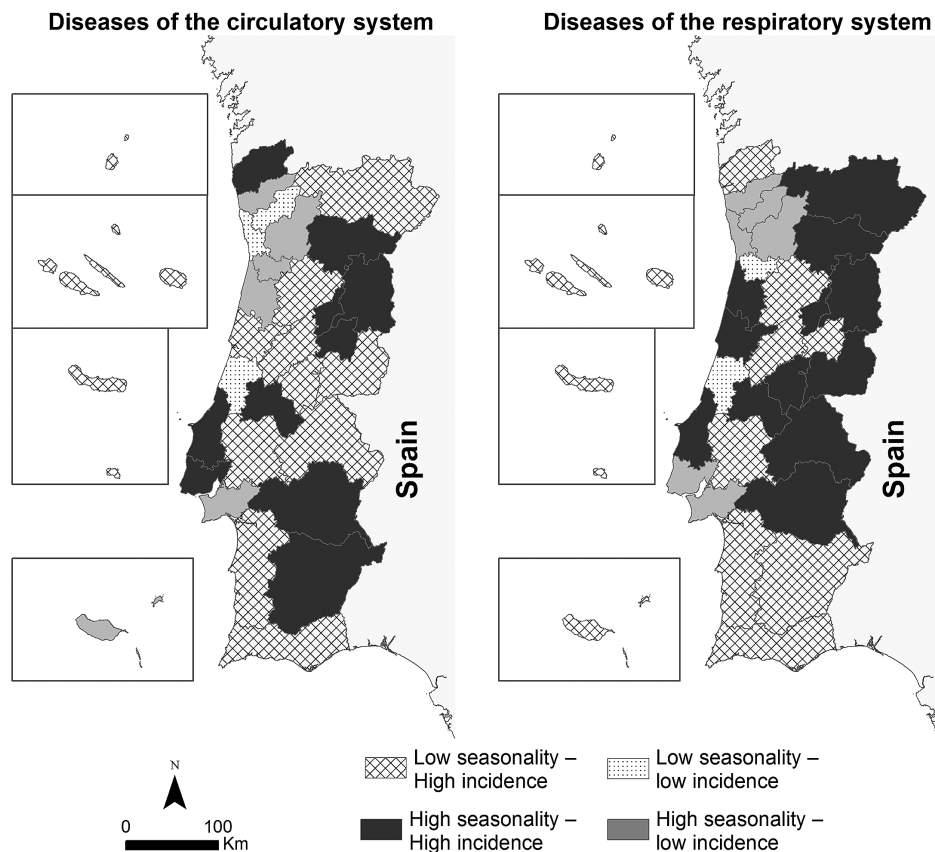


**Fig. 4.** Diseases of the respiratory system  
*Source:* Own elaboration based on data from the Statistics Portugal

### 3.4. Relationship between seasonal mortality and overall mortality

Most of the regions classified as being prone to both high mortality and seasonality were inland regions (Fig. 5). It was found that about 34% of the country population lives in regions with high mortality

ty and high seasonality due to circulatory diseases, and about 22% due to respiratory diseases (Table 2). On the contrary, only about 20% of the population lives in regions with low mortality and seasonality vulnerability to the circulatory diseases and 5% of respiratory diseases. Furthermore, most of the population lives in regions with high seasonality and low cause-related mortality (25.5% due to circulatory and 52.9% due to respiratory diseases).



**Fig. 5.** Classification according to overall and seasonal mortality

Source: Own elaboration based on data from the Statistics Portuga

**Table 2.** Proportion of population living and number of regions in each vulnerability class

Seasonality   incidence	Circulatory		Respiratory	
	population	regions	population	regions
+   +	34.1%	10	21.5%	12
+   -	25.5%	6	52.9%	6
-   +	20.8%	3	20.3%	10
-   -	19.6%	11	5.3%	2
Total	100%	30	100%	30

Source: Own elaboration based on data from the Statistics Portugal

#### 4. Discussion

Seasonal patterns of mortality and morbidity are a well-known phenomenon in many regions and countries worldwide (Burkart et al., 2011). Portugal has a seasonal mortality pattern similar to other European countries which is marked by a winter increase (Rau, 2006). In Portugal, since 2000 to 2009, about 86000 excess winter deaths were recorded (accounting for a seasonal increase of 27%). Portugal has the worst results in Europe, with even higher excess winter mortality than the other Mediterranean countries (Eurowinter Group, 1997; Healy, 2003; Rau, 2006).

Although the seasonal mortality pattern is related to weather conditions, there are several non-atmospheric factors, such as cultural, behavioral and socio-economic aspects that play a major role in explaining the winter increase in mortality (Healy, 2003; Rau, 2006). Surprisingly, countries with mild winters face higher excess winter mortality than those with harsh weather conditions (Eurowinter Group, 1997). It is acknowledged that in these countries there is a better adaptation to cold, both physiological and social (Hajat et al., 2007); people living in colder climates are less vulnerable to cold, they wear warmer clothes and know how to protect themselves better (Burkart et al., 2011). Thus, it means that at least part of the excess winter death could be avoidable, and so the seasonal mortality increase should be considered an important public health issue.

In Portugal, the winter mortality peak results mainly from the winter increases of respiratory and circulatory diseases (together they represent 70% of all EWM). The respiratory diseases had the strongest seasonal increase, but, as they are not the main cause of death, the highest EWD toll was in the circulatory system diseases. This pattern was also found in other European countries such as France (Boulay et al., 1999), the Netherlands (Kunst et al., 1991), Spain (Ballester-Díez et al., 1997), England (Lawlor et al., 2000), New Zealand (Davie et al., 2007), Denmark (Rau, 2006), among others. In fact, the exposure to cold causes several biomedical reactions in the human body; it can lead to vasoconstriction or haemoconcentration, which increases the risk of death due to a circula-

tory system disease (Eurowinter Group, 1997; Keatinge, 2002). The winter mortality increases through respiratory diseases are generally attributed to the adverse effects of cold on the immune system's resistance to infections and to the fact that low temperatures assist survival of bacteria in droplets (Eurowinter Group, 1997). The several biological factors are inter-related, there is a relationship between respiratory infection and myocardial infarction or strokes (Clayton et al., 2011).

The seasonality (expressed by the EWD index) and the winter burden (expressed by the EWD rate) have different geographical patterns in Portugal. In regions with low overall mortality, the EWD rate will always be small, but, as the EWD index varies according to the distribution of death over the year, it is not influenced by the overall mortality. The spatial patterns of the EWD rate and the overall mortality rate have a strong positive association. This association may suggest that the determinants of the disease can also be important variables to explain the geographical pattern of the EWD rate. Unhealthy behaviours (e.g. alcohol consumption, smoking, sedentary habits, stress, diet), socioeconomic conditions (e.g. poor housing, low education, low income) and biological characteristics (e.g. sex, age) are often described as increasing the risk of disease. Therefore, the role of cold weather, as a trigger factor for several diseases, is more important within the more vulnerable population groups.

The seasonal patterns are more difficult to explain; it is obvious that temperature and thermal comfort are two very different parameters, being the last more important to explain the winter seasonal increase. The exposure to cold is strongly related to socioeconomic factors and behavior (Gemmell et al., 2000), but the extent of how these factors contribute to the seasonal mortality is unclear (Davie et al., 2007); Healy (Healy, 2003) documented the consequences of poverty, deprivation and fuel poverty on the increase of cold exposure; Aylin et al. (2001) stressed the importance of using central heating; similarly, Ballester (2003) pointed the improvements in housing conditions as a significant protective measure; also Goodwin (2000) highlighted the adoption of adequate behaviors and appropriate clothing to protect from cold.



To identify the regions where it is critical to intervene, the EWD index and the overall mortality should be addressed together. Only by combining them it is possible to identify the appropriate measures and policies to mitigate this public health issue. The expected health gains from the application of protective measures and policies designed to tackle the impacts of cold weather are greater in regions with high mortality and seasonality (where the exposure to cold weather is

an important trigger factor), and where intervention is a priority. The regions with high mortality and low seasonality should be monitored carefully, because as the vulnerability to the disease is higher; even a small increase in the vulnerability to cold weather could have a strong impact on the number of EWD. The regions with low seasonality are somehow protected from seasonal factors, but since Portugal is a country with the highest seasonal increase in Europe, this assumption of low seasonality must be put into perspective (table 3).

**Table 3.** Synthesis table

Mortality  Seasonality	Relation between seasonality and mortality
+   +	High mortality and seasonality. The risk factors of the disease and the seasonality are combined. The cold is an important trigger factor
-   +	Low mortality and high seasonality. There is high vulnerability to seasonal risk factors but some level of protection from the disease. The impact of cold as a trigger factor is less important because of the lower incidence.
+   -	High mortality and low seasonality. High vulnerability to the disease, but the winter increase is not higher. However, as the incidence is higher, one small increase in cold exposure can represent an important seasonal burden
-   -	Low mortality and low seasonality. This combination suggests that there seems to be some protection from the risk factors of the disease and seasonality.

Explanation: “+” - overall mortality and/or seasonality higher than the country level; “-” - overall mortality and/or seasonality lower than the country level

Source: Own elaboration

## Limitations of the study

This study has some limitations. The access to monthly mortality data was only possible without age disaggregation, thus not allowing for the calculation of standardized indexes. Therefore, these results are not controlled for differences in age distributions.

## 5. Conclusion

This research has studied the seasonal mortality patterns in Portugal. There were important winter increases in mortality, mainly in circulatory and respiratory diseases. Important regional differences were observed in the EWD rate and index (inland

regions tend to have higher EWD rate and EWD index). The amount of EWD is related to the determinants of the disease, but the seasonality is not fully explained by those factors. These results highlight the seasonal burden and the vulnerability to cold as an important determinant of health in Portugal, where winter weather conditions are generally underrated compared to summer heat.

EWD can be successfully prevented, or at least decreased, through proper policies and interventions. Cold-related policies, aiming to reduce the exposure to cold weather conditions, should be considered in environmental health programs and should be part of health promoting policies. In some countries, such as Scotland and the UK, exposure to cold weather has been acknowledged as a public health priority and

policies were set to improve housing conditions and combat fuel poverty. In Portugal similar measures could also contribute to decreasing the number of EWD; however, further research is still needed to better understand the regional disparities and the ways in which socioeconomic conditions influence the vulnerability to cold weather.

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## References

- Alcorn, K., Gerrard, J., Macbeth, D. and Steele, M., 2013. Seasonal variation in health care-associated bloodstream infection: increase in the incidence of gram-negative bacteremia in nonhospitalized patients during summer. In: *American Journal of Infection Control*, Volume 41, Issue 12, pp. 1205–1208. DOI: <http://dx.doi.org/10.1016/j.ajic.2013.05.019>
- Almendra, R., Santana, P., Vasconcelos, J. and Freire, E., 2015. Seasonal mortality patterns due to diseases of the circulatory system in Portugal. In: *Geography, Environment, Sustainability*, Volume 1, Issue 8, pp. 71–77.
- Aylin, P., Morris, S., Wakefield, J., Grossinho, A., Jarup, L. and Elliott, P., 2001. Temperature, housing, deprivation and their relationship to excess winter mortality in Great Britain, 1986–1996. In: *International Journal of Epidemiology*, Volume 30, Issue 5, pp. 1100–1108. DOI: <http://dx.doi.org/10.1016/j.proenv.2011.03.019>
- Ballester, F., 2003. Weather, climate, and public health. In: *Journal of Epidemiology & Community Health*, Volume 57, Issue 10, pp. 759–760. DOI: <http://dx.doi.org/10.1136/jech.57.10.759>
- Ballester-Díez, F., Corella-Piquer, D., Pérez-Hoyos, S., Hervás-Hernandorena, A. and Merino-Egea, C., 1997. Seasonal variation in mortality in the city of Valencia, Spain. In: *Salud Publica de Mexico*, Volume 39, Issue 2, pp. 95–101.
- Bhaskaran, K., Hajat, S., Haines, A., Herrett, E., Wilkinson, P. and Smeeth, L., 2009. Effects of ambient temperature on the incidence of myocardial infarction. In: *Heart*, Volume 95, Issue, 21, pp. 1760–1769. DOI: <http://dx.doi.org/10.1136/hrt.2009.175000>
- Boulay, F., Berthier, F., Sisteron, O., Gendreike, Y. and Gibelin, P., 1999. Seasonal Variation in Chronic Heart Failure Hospitalizations and Mortality in France. In: *Circulation*, Volume 100, Issue 3, pp. 280–286. DOI: <http://dx.doi.org/10.1161/01.CIR.100.3.280>
- Bousquet, J., Dahl, R. and Khaltayev, N., 2007. Global alliance against chronic respiratory diseases. In: *Allergy*, Volume 62, Issue 3, pp. 216–223. DOI: <http://dx.doi.org/10.1111/j.1398-9995.2007.01307.x>
- Burkart, K., Khan, M.H., Krämer, A., Bretnier, S., Schneider, A. and 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. *International Journal for Equity in Health*, 10, 32. DOI: <http://dx.doi.org/10.1186/1475-9276-10-32>
- Chinn, S., Jarvis, D. and Burney, P., 2002. Relation of bronchial responsiveness to body mass index in the ECRHS. European Community Respiratory Health Survey. In: *Thorax*, Volume 57, Issue 12, pp. 1028–1033. DOI: <http://dx.doi.org/10.1136/thorax.57.12.1028>
- Clayton, T.C., Gaskin, M. and Meade, T.W., 2011. Recent respiratory infection and risk of venous thromboembolism: case-control study through a general practice database. In: *International Journal of Epidemiology*, Volume 40, Issue 3, pp. 819–827. DOI: <http://dx.doi.org/10.1093/ije/dyr012>
- Dahlöf, B., 2010. Cardiovascular disease risk factors: epidemiology and risk assessment. In: *American Journal of Cardiology*, Volume 105, Issue 1 Suppl, pp. 3A–9A. DOI: <http://dx.doi.org/10.1016/j.amjcard.2009.10.007>
- Davie, G.S., Baker, M.G., Hales, S. and Carlin, J.B., 2007. Trends and determinants of excess winter mortality in New Zealand: 1980 to 2000. In: *BMC Public Health*, Volume 7, pp. 263. DOI: <http://dx.doi.org/10.1186/1471-2458-7-263>
- Donaldson, G.C. and Keatinge, W.R., 1997. Mortality related to cold weather in elderly people in southeast England, 1979–94. In: *British Medical Journal*, Volume 315, Issue 7115, pp. 1055–1056. DOI: <http://dx.doi.org/10.1136/bmj.315.7115.1055>

- 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. In: *Lancet*, Volume 349, Issue 9062, pp. 1341–1346. DOI: [http://dx.doi.org/10.1016/S0140-6736\(96\)12338-2](http://dx.doi.org/10.1016/S0140-6736(96)12338-2)
- Gemmell, I., McLoone, P., Boddy, F., Dickinson, G.J. and Watt, G.C.**, 2000. Seasonal variation in mortality in Scotland. In: *International Journal of Epidemiology*, Volume 29, Issue 2, pp. 274–279. DOI: <http://dx.doi.org/10.1093/ije/29.2.274>
- Goodwin, J.**, 2000. Cold stress, circulatory illness and the elderly. In: *Cutting the Cost of Cold: Affordable Warmth for Healthier Homes*. London ; New York: E& FN Spon, pp. 47–60.
- Hajat, S., Kovats, R.S. and Lachowycz, K.**, 2007. Heat-related and cold-related deaths in England and Wales: who is at risk? In: *Occupational and Environmental Medicine*, Volume 64, Issue 2, pp. 93–100. DOI: <http://dx.doi.org/10.1136/oem.2006.029017>
- Healy, J.D.**, 2003. Excess winter mortality in Europe: a cross country analysis identifying key risk factors. In: *Journal of epidemiology and community health*, Volume 57, Issue 10, pp. 784–789. DOI: <http://dx.doi.org/10.1136/jech.57.10.784>
- Johnson, H. and Griffiths, C.**, 2003. Estimating excess winter mortality in England and Wales. In: *Health Statistics Quarterly*, Volume 20, pp. 19–24.
- Keatinge, W.R.**, 2002. Winter mortality and its causes. In: *International Journal of Circumpolar Health*, Volume 61, Issue 4, pp. 292–299.
- Kunst, A.E., Looman, C.W. and Mackenbach, J.P.**, 1991. The decline in winter excess mortality in The Netherlands. In: *International Journal of Epidemiology*, Volume 20, Issue 4, pp. 971–977. DOI: <http://dx.doi.org/10.1093/ije/20.4.971>
- Lawlor, D., Harvey, D. and Dews, H.G.**, 2000. Investigation of the association between excess winter mortality and socio-economic deprivation. In: *Journal of public health medicine*, Volume 22, Issue 2, pp. 176–181. DOI: <http://dx.doi.org/10.1136/jech.56.5.373>
- McKee, C.M.**, 1989. Deaths in winter: Can Britain learn from Europe? In: *European Journal of Epidemiology*, Volume 5, Issue 2, pp. 178–182. DOI: <http://dx.doi.org/10.1007/BF00156826>
- Rau, R.**, 2006. Seasonality in Human Mortality: A Demographic. Berlin: Springer.
- Vasconcelos, J., Freire, E., Almendra, R., Silva, G.L. and Santana, P.**, 2013. The impact of winter cold weather on acute myocardial infarctions in Portugal. In: *Environmental Pollution*, Volume 183, pp. 14–18. DOI: <http://dx.doi.org/10.1016/j.envpol.2013.01.037>
- Vasconcelos, J., Freire, E., Morais, J., Machado, J.R.R. and Santana, P.**, 2011. The health impacts of poor housing conditions and thermal discomfort. In: *Procedia Environmental Sciences*, Volume 4, pp. 158–164. DOI: <http://dx.doi.org/10.1016/j.proenv.2011.03.019>
- Wilkinson, P., Pattenden, S., Armstrong, B., Fletcher, A., Kovats, R.S., Mangtani, P. and McMichael, A.J.**, 2004. Vulnerability to winter mortality in elderly people in Britain: population based study. In: *British Medical Journal*, Volume 329, Issue 7467, pp. 647. DOI: <http://dx.doi.org/10.1136/bmj.38167.589907.55>

