TRUE – ECOCENTRIC TERRITORY RISK UNITS: CIRCULATORY AND RESPIRATORY DISEASES AGGRAVATION IN PORTO*

Maria Augusta Fernández Moreno
PHD student at Salamanca University, Faculty of Geography and History
Mariaaugusta_fernandez@yahoo.com

Ana Monteiro
Departamento de Geografia, Faculdade de Letras da Universidade do Porto
CITTA Project, PTDC/SAU-ESA/73016/2006
anamt@letras.up.pt

Vânia Carvalho
PTDC/SAU-ESA/73016/2006
carvalho.vania@gmail.com

Glória Gonçalves
PHD student of Social Sustainability and Development at Universidade Aberta
goncalves.gloria@gmail.com

ABSTRACT

This paper contributes to understand the aggravation of circulatory and respiratory diseases from an ecocentric point of view through a territorial approach. Instead of considering natural phenomena as external to the territory as in conventional natural risk approach, the integrated analysis of social and environmental - in this case thermal - factors, in the very unit of analysis, reveals possible risk scenarios under which aggravation may occur.

Keywords: Heat and cold waves, risk, territory, respiratory circulatory diseases, temperature, climate.

RESUMO

TRUE - Unidades Territoriais de Risco: o agravamento das doenças circulatórias e respiratórias no Porto - Com este artigo pretende-se contribuir para a compreensão do agravamento das doenças circulatórias e respiratórias sob um paradigma ecocéntrico com um enfoque territorial. Em vez de considerar os fenómenos naturais como externos ao território, como acontece convencionalmente no domínio dos riscos naturais, a analise integrada dos factores social e ambiental - neste caso temperatura - na própria unidade de análise revela-se útil para a identificação de prováveis cenários de risco onde o gravamento pode ocorrer.

Palavras-chave: Ondas de calor e vagas de frio, risco, território, doenças circulatórias e respiratórias, temperatura, clima.

RESUMEN

TRUE – Unidades Territoriales de Riesgo: el agravamiento de las enfermedades circulatorias y respiratorias en Porto - Este artículo contribuye a la comprensión del agravamiento de las enfermedades circulatorias y respiratorias desde un paradigma ecocéntrico con un enfoque territorial. En vez de considerar los fenómenos naturales como externos al territorio, como sucede convencionalmente en el dominio de los riesgos naturales, el análisis integrado de los factores social y ambiental - en este caso específicamente temperatura - en la propia unidad de análisis permite identificar escenarios probables de riesgo donde el agravamiento ocurre.

Palabras clave: Ondas de calor y frío, riesgo, territorio, enfermedades circulatorias y respiratorias, temperatura, clima.

RÉSUMÉ

*TRUE - Unités Territoriales de Rique: l'aggravation des maladies respiratoires et circulatoires à Porto - A*vec cet article on a l'intention d'apporter une contribution à la compréhension de l'aggravation des maladies circulatoires et respiratoires dans le cadre d'un paradigme écocentrique avec une approche territoriale. Au lieu de considérer les phénomènes naturels comme externes au territoire, comme l'on fait conventionnellement dans le domaine des risques naturels, l'analyse intégrée des facteurs social et environnemental – en l'occurrence la température – dans l'unité même d'analyse se révèle utile pour l'identification de scénarios de risques probables où l'aggravation peut se produire.

Mots-clé: Vagues de froid et de chaleur, risque, territoire, maladies circulatoires et respiratoires, température, clima.

Introduction

Respiratory and circulatory diseases are in the top of the list of causes of death in Europe. The 2012-2016 Portuguese Health Plan reports that the circulatory (32%) and respiratory (11%) diseases, besides cancer (23%), are the main causes of death maintaining the tendency reported in the 2004-2010 Health Plan.

Wondering if it is possible to recognize these tendencies in the territory, a search of relevant factors that contribute to the progression of circulatory and respiratory diseases was carried on. These factors are diverse and largely investigated under both natural and socioeconomic points of view. In Portugal, extensive research was developed since early twentieth century, when the creation of the Assistance for Tuberculosis in Northern Portugal.

To choose the variables to work with it was taken in account its condition of being observable from a territorial point of view, besides, they have to be registered along the time, like in the census and meteorological information.

Among natural environmental factors, main concern for this study is outdoor temperature, which relationship with the referred diseases is mainly studied in the form of cold spells (Kysely *et al*., 2009; Díaz e*t al*., 2005; Monteiro *et al*., 2013a) and heat waves (Hajat & Haines, 2002; Rey *et al*., 2007; Monteiro *et al.,* 2013b) and its combined influence (Huynen *et al*., 2001; Revich & Shaposhnikov, 2008). On the other hand, the influence of socioeconomic factors (Adler *et al*., 1994; Rogers *et al.,* 1996) has been largely studied, but even though, it continuous to be in debate, as Adler says: "*there is a burgeoning literature in this area, but a number of unresolved issues remain*" (Adler & Rehkopf, 2008:235) Among the innumerous socioeconomic factors, unemployment (Martikainen, 1990; Bethune, 1997) and outdoor work (Kotaniemi *et al*., 2005); (d' Amato *et al*., 2001) (Tüchsen *et al*., 2006) seem to be relevant; family size is usually used as a mean to adjust the family income or measuring the crowding index (Kaplan & Keil, 1993:1974) (Viegi *et al*., 2001:10). And, definitively, it is largely demonstrated that age is a risk factor and it is strongly associated with chronic diseases like in the chronic obstructive pulmonary disease (Kaplan & Keil, 1993).

The better we understand the risks, the lesser the damage will be. It seems that focusing on the territory as a hole, not just the negative output, in this case the illness, the risk construction can be better understood. Under a territorial point of view, the characterization of a risk scenario has the advantages of: (1) considering the equilibrium of the socio-natural system; (2) the risk patterns results from the combination of both, natural phenomena and social processes; (3) the risk

is contemplated as a continuous process where the disastrous events are not the core but milestones; (4) it facilitates a temporal-spatial analysis.

Then, analyzing the risk under a systemic approach the analysis focuses on the causes instead of the outputs. Also, the approach is no longer anthropic but ecocentric: nature and men belong to the same territory and jointly generate the risks. Then, it is possible to see that the health risk is not only determined by natural phenomenon like the intensity of a heat wave. It is the result of the accumulation of multi unbalanced human and natural forces at local hot spots capable to disrupt the territory equilibrium.

The observation scale is another aspect to take in account for better understanding the risk in the territory. The accuracy of the risk observations varies upon the researcher proximity or distance from the territory. The proximity reveals the heterogeneity of the at risk area and lets reach the hot spots where risk stockpiles. Then, local level is mandatory to understand the construction of risk processes.

These concepts were applied, through the TRUE methodology (Fernández Moreno, 2013) in Porto city in northern Portugal. The purpose of the study is to identify territorial risk patterns that contribute to circulatory and respiratory diseases aggravation during the period 2000-2007.

Background and Methodology

Then, how do we understand the risks of the territory at the local level, being so diverse and chaotic in space and time?

An ecocentric approach

Instead of approaching risks with the conventional focus, which reads the negative forces called hazards as extrinsic, and vulnerability as intrinsic forces to the subject at risk; we focus on the territory as a whole system where risk is inherent to it. Human beings and Nature are equally part of the territory with their positive and negative forces. Lovelock, in the Gaia theory (J. Lovelock, 2000) states that the biosphere –including human kind- and the physical components of the Earth are closely integrated to form a complex interacting system that maintains the climatic and biogeochemical conditions on Earth in a preferred homeorhesis. Each component has positive and negative aspects or complementary forces. This can be explained with the Chinese philosophical principle of ying-yang: the search of equilibrium between these two forces arise movement and change. Natural phenomena and human beings contain both. Natural phenomena are favorable for human life, but it

is not its unique role. In the case of the atmosphere, under certain conditions, it guaranties human life; but heat waves and hurricanes make part of its unstable nature too. It is also applicable for human beings. Human positive forces work to guaranty the permanence of human life, but also, its negative forces are destructive for Nature, and also for its own species. It is like when we have a coin, we recognize each side of the coin, but we consider the coin as a whole and not just one side.

The territory under an ecocentric approach

Under this approach, natural phenomena and human kind are considered equal members of the territory. It is possible to identify factors of different natures that make part of the territory (fig. 1): natural, social, socio-natural, individual, etc.
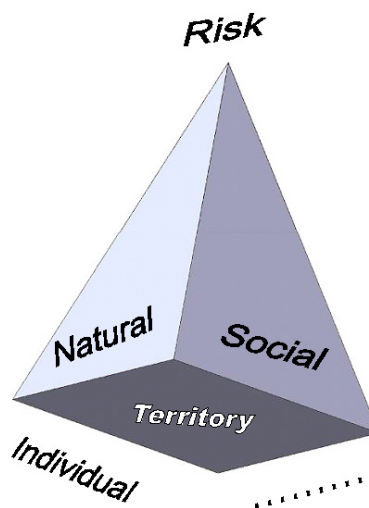

Fig. 1 – Under an ecocentric approach, several factors intervene in the construction process of risk, where natural phenomenon and human kind have the same weight, because both belong to the territory.

The territory is the effect of multiple factors relationship (Painter, 2010). Therefore, under an ecocentric point of view, the territory defined by power relationships (territoriality) includes all human and non-human components. In fact, we see in the territory the exercise of power of both natural phenomena and social beings, in which extreme episodes are armies in action to dominate the territory.

The ecocentric approach applied to risk

Because our focus is on risk, the analysis takes in account the negative aspects of the territory without resorting to hazards and vulnerabilities. In the literature the risk factors are classified into hazards and vulnerabilities, depending upon the point of view of the researcher. When Dauphiné (2004) refers to social and individual vulnerabilities or Brooks (2003) mentions the biophysical

vulnerability, or Lavell (2003) refers to socio-natural hazard, it seems that these are attempts to clarify the relation between hazards and vulnerabilities. From our point of view, the fact of being a negative aspect is enough explicative for the factor adverse contribution to the balance of the territory.

Then, the risk is a socio-natural spatiotemporal construction of the territory resulting from the accumulation of unbalanced forces. Then, each factor can be considered at the same time hazard and vulnerability from the territory stand point. Any of both aspects represents the factor's negative forces acting into the territory. The factors considered depend upon the subject at risk and the point of view of the research. Therefore, risk is the negative outcome of the synergistic effect among the intervening factors that potentially affect a subject in the territory.

Then, when calculating the risk, the variables representing natural phenomena have the same weight as those representing the negative social forces. Under this point of view, hazard and vulnerability are not anymore variables of risk, but the dual aspect of each one of the risk factors that intervene in the territory. Then, it becomes clear that the fundamental dimensions for territory risk analysis are not any more hazard and vulnerability, but space and time.

Approaching to local level risk through TRUEs

The territory is a *non-continuous geographical space of risk* that looks like a mosaic (fig.2). Each piece represents a basic territory risk unit (TRUE). It can be better explained through disasters point of view as they are the consequences of risk materialization. The disaster databases, like the EMDAT or the International Red Cross among others, usually mention figures that reflect one disaster for each natural phenomenon affecting a country, presenting the country as a whole disaster prone area. But if we do a close up, it is possible to see it in images of earthquakes where a house keeps standing up while the next one is collapsed. The damage in a disaster scenario is heterogeneous depending upon the conditions of the local at risk areas. Then, if we divide the disaster scenario into TRUEs, each one will have a different level of loss because before the negative event occurs they already had different levels of risk.

If each TRUE has its own level of risk, it seems that the risk of a territory results from the accumulation of the risk of each TRUE acting isolated or producing domino effects. Then, the territory risk variability is determined by the change of behavior of its TRUEs along the time. This notion makes the TRUE an entity that can be used as a mean for spatiotemporal comparison for risk analysis.
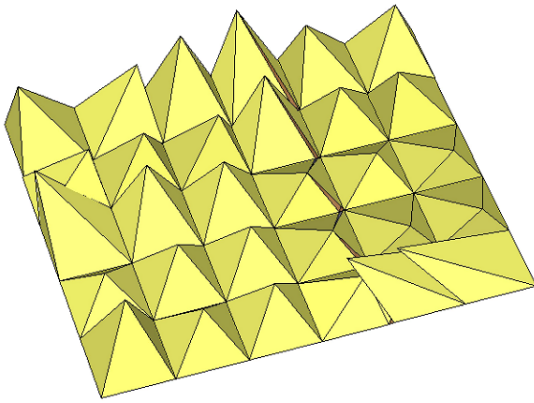
Fig. 2 –The territory risk can be seen as a mosaic of TRUEs.

Characteristics of the TRUE:

- The TRUE refers to the minimum area considered as the basic resolution unit for analysis, i.e. municipality, square, plot…

- The number of TRUEs in a study area depends upon the purpose and scale of the research.

- The size of the TRUE depends upon the observation scale defined by: the Subject at risk, the perception of the risk, the purpose of the study, the availability of the data, etc.

- The TRUE is scale invariant (P. Murphy, 1996). Although each TRUE is different, its structure does not change, independently of the observer's standpoint.

- Each TRUE is defined by: a territorial area, a Subject at risk, and n factors interacting to produce negative synergistic effects

Subject (S): There may be several subjects at risk on the same TRUE. The risk of each TRUE will be defined by a set of factors. The factors selection will depend upon the subject at risk to work with: population, buildings, social networks, natural resources, etc. By defining the subject, it is possible to avoid antagonism among factors, because the risk for a subject can be opportunity for another (N. Krueger *et al.*, 1994; A. wijkman, 1984). For example: if the TRUE is a farm, the factors for the subject "*owners*" will be different from those for the subject "*cattle*", although '*owners*' income depends on the safety of the cattle. Consequently, the number of TRUEs may equal the number of subjects identified in the same TRUE. It determines the necessity of selecting the subject to work with if the intention is to understand the level of risk for a specific subject in a defined territory during a specific period of time. Or, generate as many TRUEs as subjects considered.

Risk Factors (Fn): are processes or events that belong to the territory. Their negative synergistic effects threat the stability of the subject and as consequence the stability of the TRUE as a whole (fig.3). For example, if the subject at risk is population health, it could be possible to consider as risk factors impoverishment but also extreme outdoor temperatures. Under the point of view of the territory both factors can be considered hazards because they threat other components of the territory. At the same time, both are vulnerabilities because they are weakness of the territory components: people and atmosphere respectively.
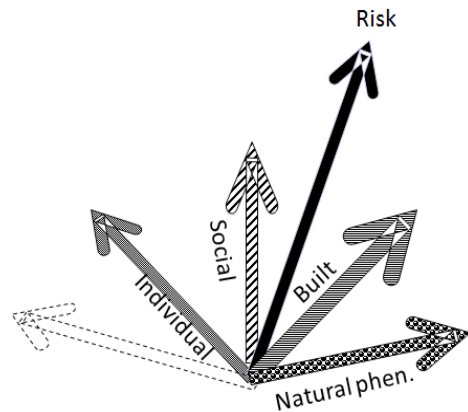

Fig. 3 – The risk level for each TRUE results from the negative synergistic effect of the factors set.

The level of risk at each TRUE

In 1979, UNDRO formalized an expression for the conceptual model of risk taking in account three components: hazard (H), elements at risk (E) and vulnerability (V).

R=H*V*E (1)

Since then, several expressions have been proposed to define the conceptual model of conflicting relations between hazards and vulnerabilities (A. Dauphiné, 2004; W. Kron, 2005):

R=H+V(2);   R=H*V (3) ;   R=f(H,V) (4)

Under the ecocentric approach proposed it is assumed that all the factors, being part of the TRUE, have the same weight. Then, the Risk in the territory (R) can be expressed as:

R = f (F$_1$, F$_2$ … F$_n$)   (5)

The risk in this approach is not considered as the probability of an outcome, but, using Aven (2011:515) words, "*the vector of the state of the system*". Each factor needs to be transformed to a comparable compatible measure to establish the relationships among them into the TRUE. Therefore, risk is expressed through the vector norm:

$$\|R\| = \sqrt{F_1^2 + F_2^2 + F_3^2 \dots}   (6)$$

When conducting this type of analysis, there are as many vectors norm as hypothetical scenarios. To validate the resulting modeling, in other words, to identify the vector norm that better explains the risk of the TRUE, it is considered the losses as outcome of the unbalanced system.

Characterization of the territory risk associated to Respiratory and Circulatory Diseases Aggravation in Porto.

Within the main diagnosis categories, the respiratory and circulatory diseases show the highest morbidity figures in Porto. They are considered a priority in Portugal's National Health Plan. There are studies that try to explain how circulatory and respiratory diseases are related to temperature (G. Bull *et al.*, 1975; S. Hajat, 2002; M. McGeehin *et al.*, 2001) or socio-economic and individual conditions (M. McGeehin *et al.*, 2001; W.R. Keatinge, 1989; S. Vandentorren, 2003). But, the negative effect on individuals is not only due to each one of these factors, but the way how they interact among them, increasing the risk of disease. They reinforce each other.

That is the case of respiratory and circulatory diseases. They are consequence of a large variety of variables. In the case of Porto, to make the reconstruction of the risk scenario feasible it was selected a narrowed group of variables to characterize the territory risk that contributes to the aggravation of these diseases. The negative effect of the interaction of some natural and socio-economic conditions was modeled applying the TRUE methodology at the parish level, during the period 2000-2007.

For validation, the results were confronted with hospital admissions for respiratory and circulatory diseases during the same period.

The Porto's TRUE

The parish is considered the basic territorial risk unit for this case study. The 41.66 km² of Porto municipality are divided into 15 parishes. Cedofeita, Se and Bonfim, all of them located in the downtown, present the highest population density (fig. 4).

Fig. 4 – Parishes of Porto and population density per hectare. Data source: INE, Census 2001.

The Subject

The health of the resident population constitutes the subject at risk. By the 2011 census, Porto population is 11% less than the 263.131 inhabitants registered in the Census 2001, and this last one already registered a decreasing tendency of 13% for the period 1991-2001. Another outstanding characteristic of the resident population is aging. The aging index for Census 2011 is 194%, notably higher that the already high 166% registered by Census 2001, and high far from its Metropolitan Area average of 79%. In 2001, Aldoar parish was the only one that showed equilibrium between youth and aging (fig. 5).
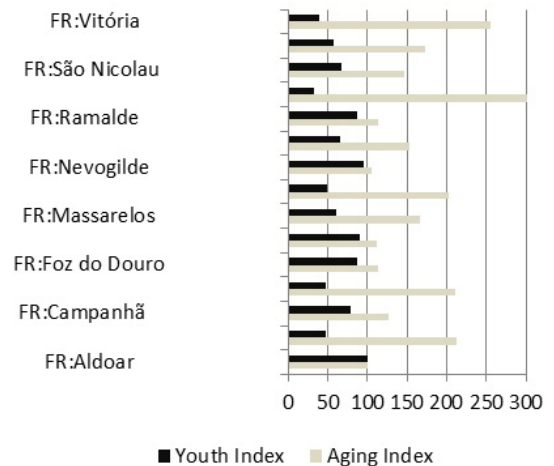
Fig. 5 – 2001 Porto Aging Index.
Data source: INE, Census 2001.

Risk Factors

Three main factors were considered to model the territory risk whose consequences could contribute to the aggravation of some circulatory and respiratory diseases: social (S), individual (I) and natural (T).

Social Factor is considered as a collective condition of risk that disables, immediately or potentially, affected groups, in meeting their welfare in a socio-historical and cultural context (L. Rygel *et al.*, 2006). This factor is defined by the following indicators: illiterate population, unemployed population and family size.

The modeling shows that the worst values for the social factor are concentrated in the downtown, specifically in the oldest parishes located closer to the Douro River. Instead, the parishes located at the west and closer to the sea show the best social factor (fig. 6).

Individual Factor is considered a function of individual's behaviors and their own socio-economic conditions that put their health stability at risk. The indicators considered are: age as an indicator of susceptibility, and outdoor workers and buildings with inefficient isolation as indicators of exposition to outdoor temperature.
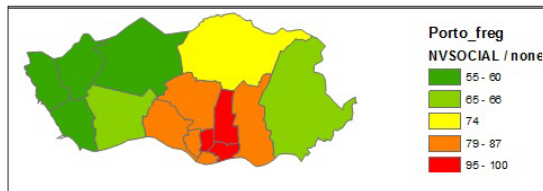
Fig. 6 – Social Factor in Porto parishes.
Data source: INE, Census 2001.

As in the Social Factor, some of the oldest parishes together with those located at the east, upstream of the Douro River, show the worst Individual Factor (fig. 7).
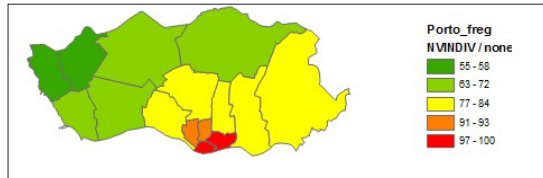

Fig. 7 – Individual Vulnerability in Porto parish.
Data source: INE, Census 2001.

Natural Factor: There is a large scientific production that studies the relation of outdoor temperature to respiratory and circulatory diseases (PTDC/SAUESA/73016/2006 Project). Then, it is clear that extreme episodes of heat and cold temperatures will contribute to better characterize this risk scenario. But, temperature in urban areas is modified by the built environment. It is distributed in urban heat islands. The Porto urban heat islands were described by Monteiro (1997, 2013a, 2013b) and for this scenario they were calculated using temperature itinerant monitoring carried on in the hottest hours of the 08/04/98. For cold temperatures we used the same approach as for urban heat islands building up a sort of cold urban islands from the itinerant temperature monitoring held in the coldest hours of 01/22/98. Then, these urban temperature islands were recalculated to fit into parish to make them compatible with the Social and Individual Factors for further calculation. Hence, three different Natural Factors were considered: cold, heat and heat+cold factors that will result in three different TRUEs. In figure 8 it is possible to recognize the differences of temperature patterns. The heat values are concentric, being the highest temperatures concentrated in the middle of the urban mass, while regarding cold temperatures, the further from the sea, the colder it gets. When both groups of islands are joined, the eastern parishes appear to be the ones that concentrate the more significant values of heat and cold islands.

The heat severity is analyzed through the Heat Index. The Heat Index (L. Rothfusz, 1990; R. Steadman, 1979) equation was applied for the year series 1970-2007.The period analyzed 2000-2007 revealed characteristics of heat severity because of the number and intensity of heat days per year. In fact, 2003, 2005, 2007 and 2006
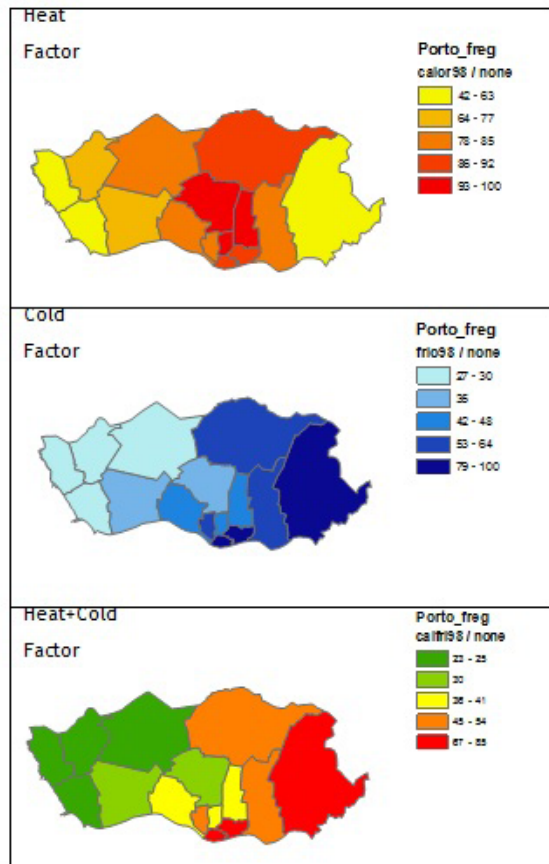

Fig. 8 – Porto heat, cold and heat-cold factors. The higher values show the extreme conditions. Source data: itinerant temperature monitoring at 08/04/98 for heat and 01/22/98 for cold temperatures. Provided by A. Monteiro.

respectively have outstanding positions in the ranking of the Heat Index as shown in Table I. Even more, two days of level 4 from the only 6 days of along the 38 years series happened in this period: one occurred in 2003 and one in 2005.

The year 2003 (Table II) appears to be not only the hottest year of the analyzed period, but the second in the 36 years series. While moderate and considerable discomfort levels are under the temperature average of the 1970-2007 series, the high and extreme discomfort levels are over the average. In consequence, the 14 days of high discomfort and the 1 day of extreme discomfort contribute significantly to the second position in the 1970-2007 Heat Index ranking.

To analyze the cold severity for the period 2000-2007, two indicators are considered: the days with at least 4⁰C lower than the daily average of the minimum temperature of the same day of the period 1978-2007 (Table III) and the days with significant daily difference of minimum temperature of at least 5⁰C, from one day to the day before (Table IV).

In addition to the rankings of heat and cold years considered individually, a ranking of unified heat and

TABLE I - Heat Index of the years 2000-2007 referred to the series 1970-2007.

Severity		Heat Index Level (days)			
Ranking	Year	1	2	3	4
...	...	...	...	...	...
2	2003	10	11	14	1
...	...	...	...	...	...
6	2005	12	19	5	1
...	...	...	...	...	...
12	2007	22	12	4	0
...	...	...	...	...	...
15	2001	14	15	4	0
...	...	...	...	...	...
17	2006	6	15	6	0
...	...	...	...	...	...
19	2004	14	14	3	0
...	...	...	...	...	...
21	2000	13	15	2	0
...	...	...	...	...	...
30	2002	19	6	3	0
...	...	...	...	...	...

Note: Heat Index is applicable when relative humidity is over 40% , temperature at shadow is >27ºC (80 ºF), and dew point >12 ºC (54 ºF)

Data source: daily maximum temperature from Serra do Pilar weather station.

TABLE II - Days of thermal discomfort according to Heat Index for year 2003.

Discomfort level			Jn	Fb	Mr	Ap	Ma	Jn	Jl	Ag	Sp	Oc	Nv	Dc	Days
Moderate	27-32°C	Level 1	0	0	0	0	2	0	2	4	3	2	0	2	15
Considerable	32 - 41°C	Level 2	0	0	0	0	3	2	1	2	3	0	0	0	11
High	41 - 54°C	Level 3	0	0	0	0	0	3	2	6	3	0	0	0	14
Extreme	54°C o más	Level 4	0	0	0	0	0	0	0	1	0	0	0	0	1

Data source: daily maximum temperature from Serra do Pilar weather station..

cold discomfort was calculated for the period 2000-2007 to understand the global discomfort severity of each year (TABLE V). It is based on the Heat Index for heat, and the Ranking of Cold Years and Daily Difference of Minimum Temperatures for cold.

Years 2003 and 2005 are in the top of the ranking of combined thermal discomfort:

— Year 2003: the combination of events of heat and cold make of this year the first most dangerous of the period 2000-2007. This was an exceptional year

TABLE III - Days with at least 4ºC lower than the daily average of the minimum temperature of the same day for the period 1978-2007.

Severity Ranking	Year	9ºC	8ºC	7ºC	6ºC	5ºC	4ºC
...	...	...	...	...	...	...	...
9	2000			7	5	10	14
...	...	...	...	...	...	...	...
11	2005		2		10	13	17
...	...	...	...	...	...	...	...
17	2006				9	11	10
18	2001			2	6	8	8
...	...	...	...	...	...	...	...
22	2007			1	4	11	11
...	...	...	...	...	...	...	...
26	2003			1	2	8	10
...	...	...	...	...	...	...	...
29	2004			1	2	6	16
30	2002					5	11

Data source: daily minimum temperature from Serra do Pilar weather station.

TABLE IV - Days with significant daily difference of minimum temperatures, from one day to the day before, for the period 2000-2007.

Ranking	Year	Δ temperatures								total
		12ºC	11ºC	10ºC	9ºC	8ºC	7ºC	6ºC	5ºC	days > 5ºC
1	2002	2	0	0	9	2	1	9	9	32
2	2003	2	1	0	3	0	0	5	12	23
3	2007	1	0	0	1	6	2	3	5	18
4	2000	0	0	0	0	3	0	5	9	17
4	2006	0	0	0	0	2	2	4	9	17
5	2001	0	0	0	0	0	2	3	13	18
5	2004	0	0	0	0	0	2	4	11	17
6	2005	0	0	0	0	0	3	2	5	10

Data source: daily minimum temperature from Serra do Pilar weather station.

TABLE V - Ranking of unified heat and cold discomfort for the period 2000-2007.

Ranking	Year
1	2003
2	2005
3	2007
4	2002
5	2000
6	2006
7	2001
8	2004

Data source: daily minimum temperature from Serra do Pilar weather station.

regarding heat, being the second hottest year in a 38 year series (1970-2007). Besides, even though 2003 merely makes the position twenty six within the ranking of cold years in a 30 years series (1978-2007), the differences between the daily minimum temperatures show extremely large intervals between one day and the day before.

— Year 2005: in the period of analysis 2000-2007, this year presents the highest level of discomfort after 2003. It is in the sixth position within the 38 year series (1970-2007) of hottest years. Regarding cold, this one is ranked eleventh within a 30 years series (1978-2007) of coldest years. Although the daily difference of temperature is one of the less significant, it registers the lowest temperatures compared with the average of the minimum temperatures of the same day of the series.

Risk scenarios

The objective of the analysis is to identify the risk scenarios that better explain the contribution of the territory for the respiratory and circulatory diseases.

The socio-economic and individual factors are constant for all the scenarios. In fact, the census 2001 is the sole source available that provides the information required to define both factors. On the other hand, in the case of the natural factor, the availability of data for outdoor temperature makes it possible to take in account the heat and cold temperatures as separated factors, and also as a combined one. Then, four scenarios were calculated as shown in fig. 9.

For all the scenarios, the oldest part of the city, where the highest values are registered, is the highest risk area. Besides, there is a tendency of higher risk values to the east of the municipality, upstream the Douro River; whereas the parishes to the west, closer to the sea, show lower levels of risks.

Validation

To validate the results, each scenario was correlated with hospital admissions normalized with relation to the resident population, for respiratory and circulatory diseases, for the period 2000-2007. Daily admissions for circulatory and respiratory diseases were obtained from the All Patient Diagnosis Related Groups (AP-DRG) – Version 21 of Biostatistics and Medical Informatics and Health System's Central Administration, Year 2011 data base of the Portuguese Health System. TABLE VI presents the respiratory and circulatory diseases selected, assuming its possible relation with the factors considered in the risk scenarios.

Results

Causes that contribute to the development of respiratory and circulatory diseases

At this point of the research, it is possible to confirm that: (1) the risk scenario that considers *social*, *individual*, and *natural factors -defined as described before- associated*

$R_1 = f$ (social factor, individual factor)

$R_2 = f$ (social factor, individual factor, natural factor associated to heat temperature)

$R_3 = f$ (social factor, individual factor, natural factor associated to cold temperature)

$R_4 = f$ (social factor, individual factor, natural factor associated to heat and cold temperature)
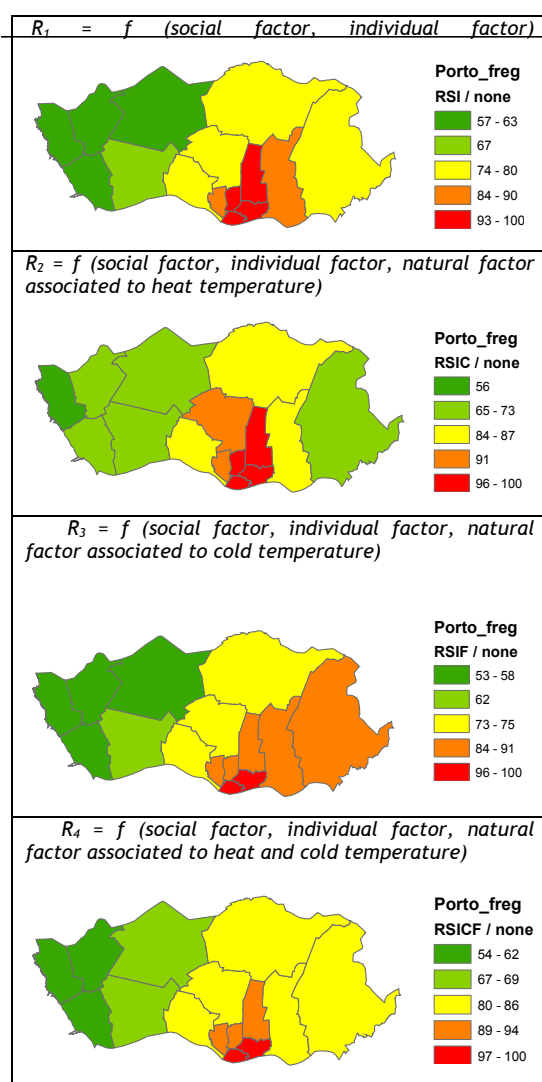
Fig. 9 – Porto risk scenarios to explain the territory contribution for respiratory and circulatory diseases risk.

TABLE VI - Respiratory and Circulatory Diseases considered for risk analysis.

Respiratory Diseases	
96+97	Bronchitis and asthma, age >17, with and without major complications.
88	Chronic Obstructive Pulmonary Disease.
89+90	Simple pneumonia and pleurisy.
Circulatory Diseases	
121	Circulatory disorders with acute myocardial infarction and major complications, discharge alive.
122	Circulatory disorders with acute myocardial infarction, without major complications, discharge alive.
123	Circulatory disorders with myocardial infarction, dead.
127	Heart failure and shock.

The correlation was calculated between each risk scenario and the normalized hospital admission in relation with the resident population. COHEN (1988) suggests that there are very good correlations within intervals [-1; -0,5] and [+0,5;1]. Even so, we consider intervals [-1; -0,7] and [+0,7;1] as very good correlation, leaving ±0,6 as indicative for future review (TABLE VII).

Source: Portugal National Health Plan 2004-2010.

TABLE VII - Correlations between risk scenarios and hospital admissions caused by respiratory and circulatory diseases for the period 2000-2007.

	Hospital Admission							
Year	00	01	02	03	04	05	06	07
Risk of								
Bronchitis and asthma (96+97)								
R_1	0,5	0,4	0,2	-0,3	0,3	0,2	0,6	0,5
R_2	0,5	0,3	0,3	-0,4	0,4	0,2	0,5	0,5
R_3	0,4	0,4	0,1	-0,2	0,2	0,1	0,6	0,6
R_4	0,4	0,3	0,2	-0,3	0,3	0,1	0,6	0,6
Chronic Obstructive Pulmonary Disease (88)								
R_1	0,2	0,5	0,6	0,7	0,3	0,6	0,5	0,2
R_2	0,2	0,4	0,6	0,6	0,3	0,6	0,5	0,1
R_3	0,3	0,4	0,7	0,8	0,3	0,5	0,4	0,3
R_4	0,3	0,5	0,7	0,7	0,3	0,6	0,4	0,3
Simple pneumonia and pleurisy (89+90)								
R_1	0,1	0,5	0,5	0,5	0,6	0,2	0,5	0,4
R_2	0,2	0,5	0,5	0,4	0,6	0,2	0,4	0,4
R_3	0,1	0,5	0,5	0,6	0,7	0,3	0,5	0,5
R_4	0,2	0,5	0,6	0,6	0,6	0,3	0,5	0,5
Circ. Disord./acute myocard/infarct. (121 122 123)								
R_1	-0,5	0,2	0,3	0,2	-0,1	-0,2	0,3	0,6
R_2	-0,4	0,2	0,3	0,3	0,0	-0,2	0,3	0,5
R_3	-0,5	0,1	0,2	0,2	0,0	-0,1	0,3	0,7
R_4	-0,5	0,2	0,3	0,3	0,1	-0,2	0,3	0,7
Heart Failure and Shock (127)								
R_1	0,5	0,7	0,5	0,6	0,5	0,8	0,7	0,6
R_2	0,5	0,7	0,5	0,6	0,6	0,9	0,7	0,6
R_3	0,4	0,6	0,5	0,7	0,4	0,8	0,7	0,6
R_4	0,4	0,7	0,5	0,7	0,5	0,9	0,7	0,6

Data source: Hospital admission statistics from the Biostatistics and Medical Informatics and health System's Central Administration database period 2000-2007

to cold temperature, is able to identify potential hot points for the development of Chronic Obstructive Pulmonary Disease; (2) the risk scenario that considers *social*, *individual*, and *natural factors* associated to joined heat-cold temperature factors is able to identify potential hot points for the development of Heart Failure and Shock Disease (127).

As expected, the observations let us confirm that not all the respiratory and circulatory diseases can be explained with the risk scenarios proposed. Even though, the Chronic Obstructive Pulmonary Disease (88) and Heart Failure and Shock (127) are clearly related to all four scenarios, when years are exceptional in thermal discomfort.

In the case of the Chronic Obstructive Pulmonary Disease (88), the best correlations are for year 2002 and 2003, mainly for R_3. Indeed, there is better correlation with cold temperatures than hot temperatures. 2002 and 2003 are the top of the years with largest drops of temperature from one day to the day before. In the other hand, the correlations for 2005 are not satisfactory. Although 2005 is one of the coldest of a series of 30 years, it does not register important episodes of temperature drops. The results suggest the importance of temperature drops as contribution for the aggravation of this disease.

Regarding to Heart Failure and Shock Disease (127), there are correlations in four of the eight years of the period analyzed in almost all scenarios. In this group of disease, years of high thermal discomfort contribute to the development of the disease, as is the cases of years 2003 and 2005. In the case of years 2001 and 2006, considered average years in terms of temperature, there is also a very good correlation. The results suggest the importance of the synergistic effect of all three factors for the case of 2001, considering that none of them is dominant. The correlation for 2006 has to be reviewed because of the bias introduced by the outdated information from census 2001. In any case, the R_4 scenario consistently shows the best correlations. Thus, it is possible to conclude that, besides the socio-economic and the individual conditions of the population, the joined heat and cold factor can be considered a better approach to the risk scenario for this disease.

In the case of Circulatory Disorders with Acute Myocardial Infarction (121, 122, 123), there is a very good correlation only for year 2007, for R_3 and R_4. The year 2007 is characterized as a hot year, being rated in the position eleven in the 38 year series (1970-2007). And, even though it is not ranked as a cold year, it registered extreme low temperature drops, after the drops of 2002 and 2003. Nevertheless, other years of the period 2000-2007 with similar extreme conditions do not show similar results for this disease. In addition, the socio-economic and individual factors are poorly represented, considering that this is information is dated 2001, six years old. Despite the good correlation, these results suggest continuing research for a risk scenario that better contributes to explain the potential causes for the development of this disease.

Bronchitis and Asthma (96+97) and Simple Pneumonia and Pleurisy seem not to be explained through the proposed risk scenarios.

The risk footprint of Porto at the parish level for respiratory (88) and circulatory disease (127)

Fig. 10 shows the potential risk for both, respiratory (88) and circulatory (127) diseases, in Porto´s parishes. The closer to year 2001, the year of the census, the more reliable is the risk scenario. Among the 15 parishes of

Porto, Aldoar, Nevogilde, Foz do Douro, Lordelo do Douro and Ramalde show the lower risk level for both disease groups. These five parishes are located to the west and register a balanced aging index.
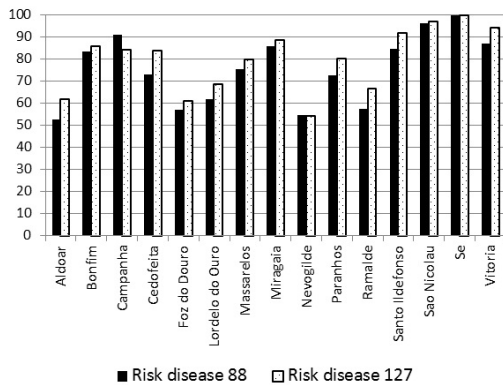
Fig. 10 – Porto parishes risk of respiratory (88) and circulatory (127) diseases.

In the other hand, Se, São Nicolau, Victoria and Santo Idelfonso parishes, located in the center of the municipality, show the highest levels of risk for both disease groups. This zone concentrates the urban islands with hottest and coldest temperatures. In addition, these parishes register the more unbalanced aging index. A possible relation to population density was avoided when reviewed the statistics. Indeed, these parishes register large disparity of population density. São Nicolau has 11 inhabitants per hectare, while Se has 98, being the less and the more densely populated of Porto respectively.

Discussion of Results

The outputs are satisfactory for this first approach to risk scenarios for respiratory and circulatory diseases in Porto, but obviously not enough. It seems necessary to review the list of indicators contemplated for each factor, and increase the scale of the TRUE, from parish to neighborhood level. The change to a more detailed level is expected to improve the outcomes and clarify some issues that are not possible to explain at this stage of the research, as pointed above at the Results.

The heat and cold urban islands were defined in August 4th, and January 22th, 1998. The date is not considered restrictive for this analysis. Even though, if new data is available, the review of outdoor temperature is contemplated in order to evaluate the changes in time it implies.

The inconclusive results for 2007 suggest the need to review the social and individual factors. Indeed, the limitation that 2001 Census information imposes to the risk scenarios for the latest years of the period could be one of the causes that explain the outcome. New risk scenarios will be elaborated with the information provided by the 2011 Census.

Conclusions

The ecocentric risk approach applied through the TRUEs methodology shows to be useful for territorial risk comparison in time and space for Porto territorial risk referred to circulatory and respiratory diseases.

The definition of each factor depends upon the subject at risk to be analyzed. In this case, the list of indicators for each one of the factors was appropriate to approach the risk scenario for two of five groups of respiratory and circulatory diseases. For groups of disease 88 and 127, the territorial risks are clearly related to the negative synergistic effect of both natural and human systems, specifically outdoor temperature and social and individual conditions. The other three groups of diseases require a different set of factors and indicators if the purpose is to identify the risk scenarios for them.

The larger scale of the TRUE, the complexity of systematization increases. At the same time, it improves the approach to the real scenario. In the other hand, smaller units facilitate interpretation, but decrease the outputs reliability.

Acknowledgements

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