Spatial Dependence of Cause-specific Mortality in Europe

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Introduction

Introduction

Study mortality differences by causes of death between Eastern and Western European countries using spatial data analysis methods.

Research based on Carraedo et al's paper "Detecting spatio-temporal mortality clusters of European countries by sex and age". International Journal for Equity in Health (2018)17:38

Data

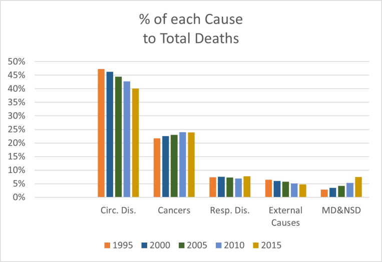
Data - (1)

Data	Our Research	Carracedo et al.'s Paper
Source of Data	World Health Organization (WHO) mortality database	Human Mortality Database (HMD)
No. of European countries	30	26
Period of Study	1995–2015	1990–2012
Age groups (for each gender)	– 40–64 65+	0–14 15–64 65–110+
Mortality rate calculated	Standardized Mortality Ratio (SMR)	Comparative Mortality Figure (CMF)

Data - (2)

Main causes of death in Europe:

- Diseases of circulatory system
- Cancers
- Respiratory diseases
- External causes
- Mental disorders & nervous system diseases



Standardized Mortality Ratio (SMR)

Standardized Mortality Ratio (SMR)

We use the indirect method of standardization to calculate the SMR.
In our research, the standard population is the set of European countries for each gender and age group.

For each cause of death, SMR is calculated as:

$$SMR_{i,x,t,g} = \frac{d_{i,x,t,g}}{E_{i,x,t,g}} \tag{1}$$

for $i \in \{1, ..., N\}$, $t \in \{1, ..., T\}$, $x \in \{x_1, x_2\}$ and $g \in \{male, female\}$
where
$d_{i,x,t,g}$ and $E_{i,x,t,g}$ are the numbers of observed deaths and the corresponding expected deaths for each European country i, age group x, year t, and gender g.

SMR - (2)

The $E_{i,x,t,g}$ is obtained as

$$E_{i,x,t,g} = m_{x,t,g} p_{i,x,t,g} \tag{2}$$

where

$p_{i,x,t,g}$ is the corresponding population for country i, age x, year t, and gender g;

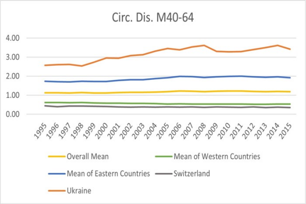
$m_{x,t,g}$ is the death rate for the standard population; namely

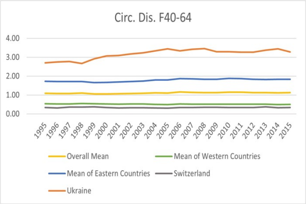
$$m_{x,t,g} = \frac{\sum_{i=1}^{N} d_{i,x,t,g}}{\sum_{i=1}^{N} p_{i,x,t,g}} \tag{3}$$

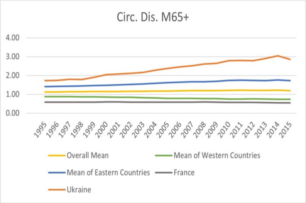
SMR $> 1 \rightarrow$ Excess deaths

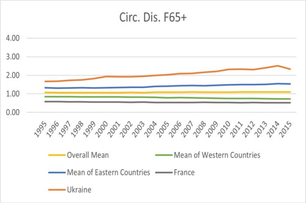
SMR Summary Results - (1)

Circulatory Diseases

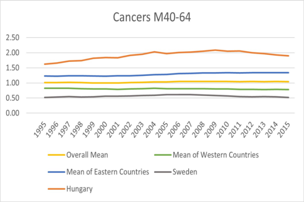


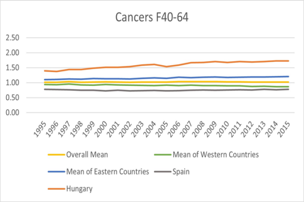


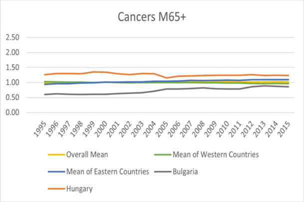


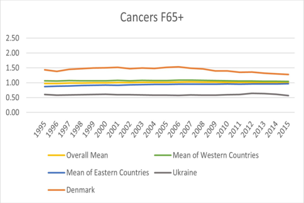


Cancers


Cancers M40-64
2.50
2.00
1.50
1.00
0.50
0.00
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
Overall Mean
Mean of Western Countries
Mean of Eastern Countries
Sweden
Hungary

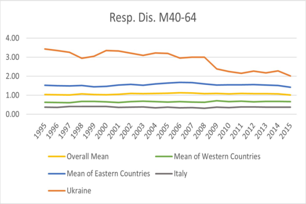

Cancers F40-64
2.50
2.00
1.50
1.00
0.50
0.00
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
Overall Mean
Mean of Western Countries
Mean of Eastern Countries
Spain
Hungary

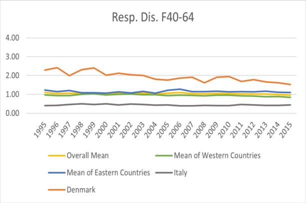

Cancers M65+
2.50
2.00
1.50
1.00
0.50
0.00
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
Overall Mean
Mean of Western Countries
Mean of Eastern Countries
Bulgaria
Hungary

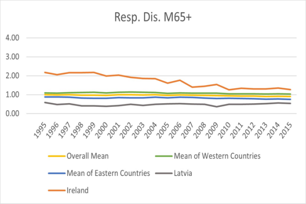

Cancers F65+
2.50
2.00
1.50
1.00
0.50
0.00
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015
Overall Mean
Mean of Western Countries
Mean of Eastern Countries
Ukraine
Denmark

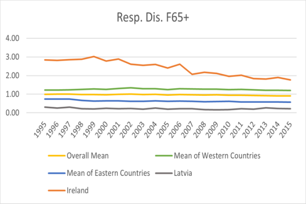
SMR Summary Results - (3)

Respiratory Diseases



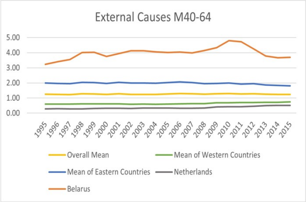


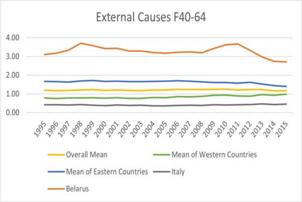


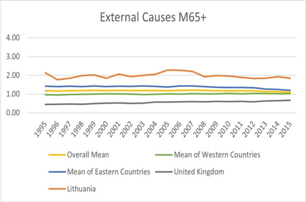


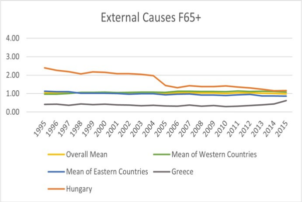
SMR Summary Results - (4)

External Causes



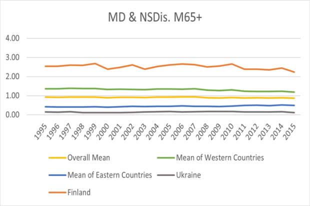


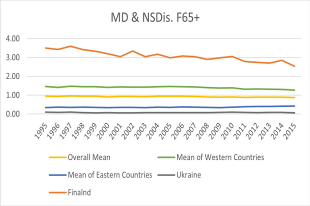




SMR Summary Results - (5)

Mental Disorders & Nervous System Diseases (Age 65+)





Global Moran's (GM) Index

Global Moran's (GM) Index

This is a summary measure of the intensity of the spatial autocorrelation between geographical units.

It is defined by:

$$GM_{x,t,g} = \frac{N \sum_i \sum_j w_{ij}(SMR_{i,x,t,g} - \overline{SMR}_{x,t,g})(SMR_{j,x,t,g} - \overline{SMR}_{x,t,g})}{\sum_i \sum_j w_{ij} \sum_i (SMR_{i,x,t,g} - \overline{SMR}_{x,t,g})^2} \tag{4}$$

where: $\overline{SMR}_{x,t,g}$ is the mean of the SMR in all countries for each group x, year t, and gender g,

$W = (w_{ij})$ is the spatial weights matrix and has the form:

$w_{ii} = 0$, $i = 1, ..., N$;

$w_{ij} = \frac{1}{n_i}$, if $j \in V(i)$;

$w_{ij} = 0$, if $j \notin V(i)$

where i and j are any two of the N countries,

n_i is the number of neighbors of i,

$V(i)$ is the set of neighbors of country i.

GM Index - (2)

Values of the GM index:

$+$ve values of the index	$\rightarrow$	$+$ve spatial autocorrelation
-ve values of the index	$\rightarrow$	-ve spatial autocorrelation
Values close zero	$\rightarrow$	absence of spatial autocorrelation

Moran's test for spatial autocorrelation:

$H_0 : GM_{x,t,g} = 0$ low p-value suggests the presence of spatial autocorrelation

GM Index - (3)

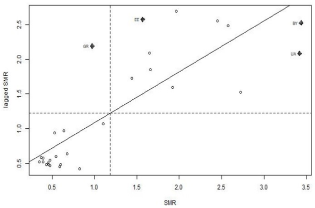
Results - Age 65+

Cause of Mortality	Year	GMI		p-value		p-value MC	
		Male	Female	Male	Female	Male	Female
All Causes	1995	0.60	0.57	1.4e-05	3.4e-05	< 2.2e-16	< 2.2e-16
	2015	0.74	0.58	1.1e-07	2.3e-05	< 2.2e-16	< 2.2e-16
Circulatory Diseases	1995	0.74	0.74	1.1e-07	1.3e-07	< 2.2e-16	< 2.2e-16
	2015	0.70	0.71	3.2e-07	2.8e-08	< 2.2e-16	< 2.2e-16
Cancers	1995	0.46	0.56	0.001	4.5e-05	0.008	< 2.2e-16
	2015	0.29	0.36	0.025	0.005	0.030	0.008
Respiratory Diseases	1995	0.39	0.62	0.002	1.1e-06	0.004	< 2.2e-16
	2015	0.32	0.47	0.016	0.001	0.030	< 2.2e-16
External Causes	1995	0.42	0.14	0.002	0.211	0.006	0.21
	2015	0.38	0.53	0.004	1.0e-04	0.002	< 2.2e-16
Mental Disorders & Nervous System Diseases	1995	0.54	0.53	5.7e-05	6.0e-05	< 2.2e-16	< 2.2e-16
	2015	0.61	0.66	6.8e-06	1.7e-06	< 2.2e-16	< 2.2e-16

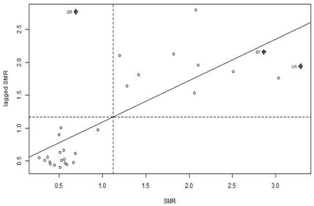
GM Scatterplots

Circulatory Diseases 2015

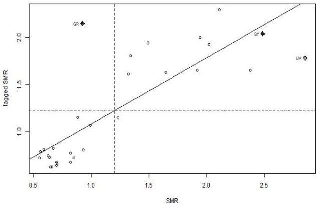
M40-64



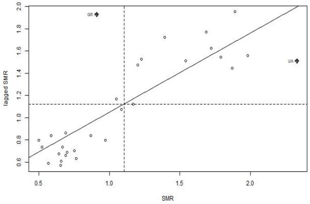
F40-64



M65+



F65+



Local Moran's (LM) Index

Local Moran's (LM) Index

Local Moran's Index is one of the Local Indicators of Spatial Association (LISA) introduced by Anselin in 1995.
Used for identification of significant local clusters.

It is defined by:

$$LM_{i,x,t,g} = \frac{(SMR_{i,x,t,g} - \overline{SMR}_{x,t,g})}{s^2(SMR_{x,t,g})} \sum_i \sum_j w_{ij}(SMR_{j,x,t,g} - \overline{SMR}_{x,t,g}) \tag{5}$$

where $s^2(SMR_{x,t,g})$ is the variance of the SMR in all of the countries for each age group x, year t, and gender g.

LM Index - (2)

LISA classification for each country and its neighborhood:

State	Country's SMR	Country's $\overline{SMR}$
1 = LL	Below average	Below average
2 = LH	Below average	Above average
3 = HL	Above average	Below average
4 = HH	Above average	Above average

A significant Local Moran's Index indicates:

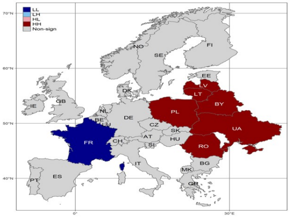
Local clusters: $+$ve $LM_{i,x,t,g}$ indicates HH or LL cluster countries

Spatial outliers: -ve $LM_{i,x,t,g}$ indicates HL or LH cluster countries

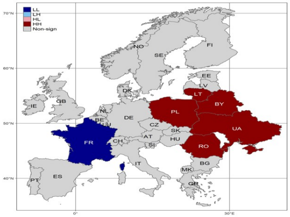
LISA Cluster Maps - (1)

All Causes 2015

M40-64



F40-64



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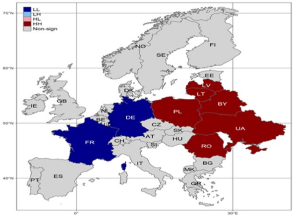

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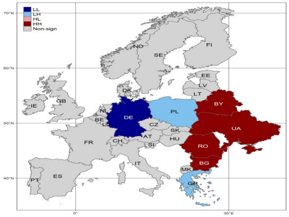
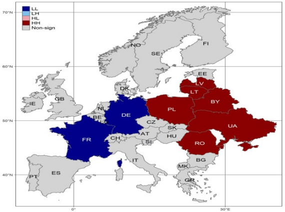


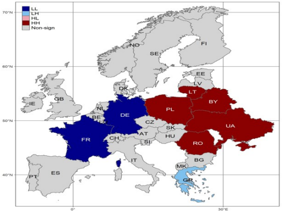
LISA Cluster Maps - (2)

Circulatory Diseases 2015

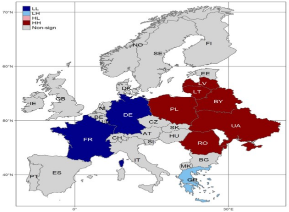
M40-64



F40-64



M65+



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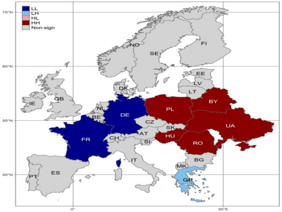
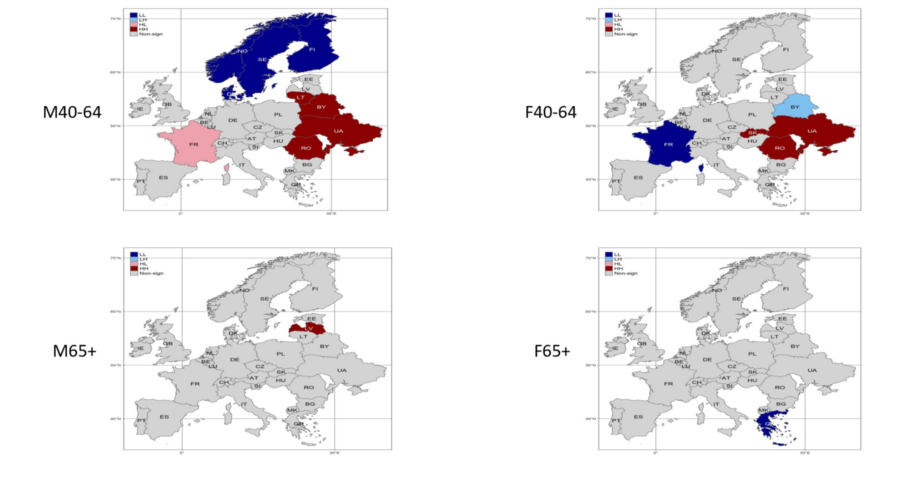


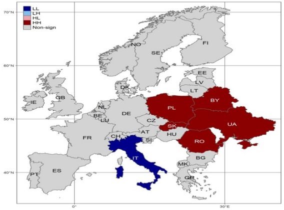
Cancers 2015



LISA Cluster Maps - (4)

Respiratory Diseases

M40-64



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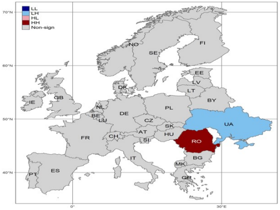
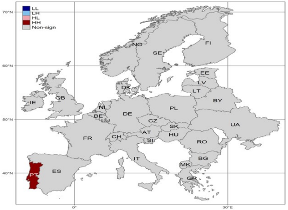


M65+



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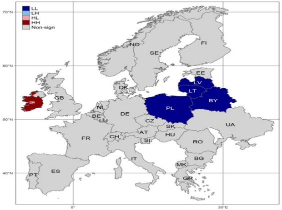
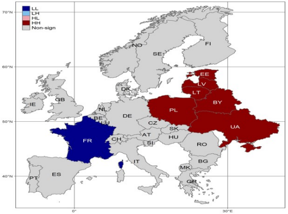
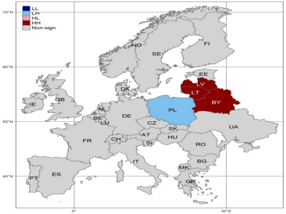


External Causes 2015

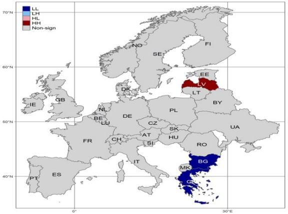
M40-64



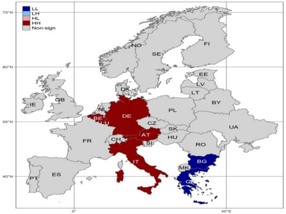
F40-64



M65+

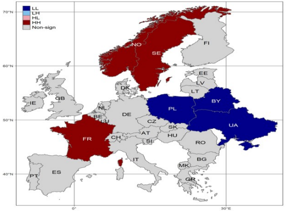


F65+

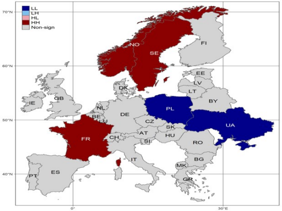


Mental Disorders & Nervous System Diseases

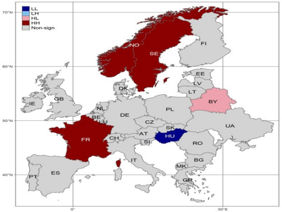
M65+
(1995)



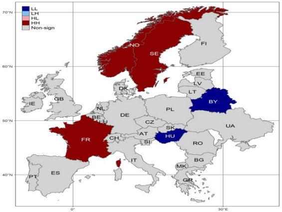
F65+
(1995)



M65+
(2015)



F65+
(2015)



Conclusion

Conclusion

Different mortality causes exhibit different spatial autocorrelation patterns.

For the age group (40-64):
For males: significant high local clusters are consistently observed in Eastern Europe among different causes (except for Mental Disorders & Nervous System Diseases). **For females:** significant high local clusters are observed in Eastern Europe only for Circulatory Diseases.

For the age group 65+
Significant high local clusters for Circulatory Diseases in Eastern Europe and Mental Disorders & Nervous System Diseases in France, Norway and Sweden for both males and females.

Spatial autocorrelation observed in overall mortlaity is due to Circulatory Diseases. However, this is expected to change with the rising mortlaity in cancers and Mental Disorders & Nervous System Diseases.

Thank you for you attention!

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