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Multivariate Spatial Association between Mortality, Unemployment, Divorce, and Crime in Jordan-2011

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Abstract

Despite the wealth of research investigating the association between socioeconomic, demographic, and health indicators in the developed countries, few and inconsistent studies investigated this association at governorate level in developing countries, such as Jordan. There is abundance in socioeconomic problems in developing countries that affect long-term health conditions and could contribute to health inequalities between socioeconomic classes.

This study investigates multivariate spatial association between the rates of mortality, unemployment, divorce, and crime across Jordan's governorates. The study seeks to determine the spatial patterns of these indicators and to examine the magnitude of the differences across governorates for 2011. The study design utilizes a multivariate cross sectional spatial analysis. The data for 2011 were obtained from a survey conducted in Jordan in 2012. A visual inspection of the spatial pattern for each indicator was shown by mapping. Lee's global and local measures for each governorate were used. A *p*-value was determined through Monte Carlo simulations to evaluate the statistical significance of each association in each governorate.

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Global and local results for each governorate were presented. No significant global spatial relationship was found. However, multiple local spatial relationships between the indicators under investigation were found significant in several western governorates. These conclusions allow identifying the disadvantaged governorates and help social and public health authorities set up plans. Efforts should, therefore, be made in the disadvantaged governorates to create awareness about the necessity of early discovery and treatment. The authors suggest that further studies are needed in these spatial relationships.

Mathematics Subject Classification: Statistics
Keywords: Spatial Association, Mortality, Unemployment, Divorce, Crime, Jordan, Lee's matrix, Simulation study, Mapping

1 Introduction

All of us know the importance of studying the strength and direction of the association between socioeconomic, socio-demographic, and health indicators (such as mortality, unemployment, divorce, and crime) in world societies. The current study investigates the multivariate spatial relationships between mortality rate (MR), unemployment rate (UR), divorce rate (DR), and crime rate (CR). The intention of the authors was to include as many socioeconomic and health indicators as possible. Unfortunately data on some indicators were not available or incomplete. The importance of studying these relationships emanates from several reasons. For instance, if the location of disadvantaged areas is known, more resources could be directed to these areas allowing faster and more efficient solutions to spatial concerns. Once these relationships are known, the goal of reducing their negative effects could be realized. The purpose of the current study is to understand the demographic and socioeconomic concerns of the Jordanian society and risk differentials over space (governorates).

The current study coincides with previous research in objectives. However, it differs in several aspects among which: study area, statistical analysis, study design, the results, and spatial analysis unit. As some areas in the developing world get richer, the possibility of spatial socioeconomic segregation increases and, therefore, the worry of increases in mortality and poor health grow.

The current study's hypothesis is as follows: there are positive and statistically significant global and local spatial associations between mortality, unemployment, divorce, and crime, across Jordanian governorates. This hypothesis postulates that the higher rates of unemployment, divorce, and/or crime, the higher the mortality rate. Higher unemployment, especially for extended durations, means disruption of income, and therefore the more likely divorce and/or crime to happen due to the inability to provide for basics of living.

The present study investigates the significance of these associations and their locations.

The local Lee's measure was discussed in some details using matrices and programing using SPLUS software which deals with theoretical implications. The practical implication is to study several important indicators that are of interest to economists, statisticians, sociologists, public health researchers, and policy makers. The study problem is of interest and deserves extensive research in developing countries due to the importance of the direct and indirect implications of socioeconomic and health indicators and their effect on life expectancy rates. In addition, there is an urgent need to identify the location of the disadvantaged governorates. Previous studies applied many statistical techniques and different methodologies but few studies, particularly in developing countries, used spatial statistics measures, which are of particular importance in the current study. Following is a brief of previous literature.

Lundin et al. (2012) and Chang et al. (2010) stated that trends in suicide, particularly among adult males, appear to be influenced by unemployment. From the point of view of an unemployed person, if that person is criminally inclined, property crime becomes an alternative for legal economic activities. Being unemployed causes a frustrations emanating from the inability to provide for the family. The level of frustration could become so great compelling the unemployed to engage in violent behavior. Geographic study by Alvaro-Meca et al. (2013) in Spain showed that areas with historically higher levels of unemployment witness higher suicide rates. Longer durations of unemployment were associated with higher male suicide rates in Australia (Milner, Page, & LaMontagne, 2013). Mäki and Martikainen (2012), in their study about Finland concluded that long-term unemployment had a causal effect on suicide rate that may be partly mediated by low income. The association between unemployment and suicide at the national level was found significant in US for the period of 1940 to 1984 (Yang & Lester, 1994). An experience of at least one job loss increased the risk of premature mortality in Denmark (Kriegbaum et al., 2009).

Lawanson and Fadare (2013) stated that socioeconomic attributes interact with and magnify health disparities in the Lagos Metropolis, Nigeria. Okposio, Unior, and Ukpeteru (2012) stated that social factors in the Niger Delta region of Nigeria played a significant role in the health status of children under-5. Tcherni (2011) showed that the effects of poverty, low education, race, and divorce rates on homicide rates in US counties were remarkably strong. At the municipal level in Japan, a decrease in healthy longevity of older people was associated with higher percentage of households consisting of single elderly persons and divorce rates, and lower socioeconomic conditions (Fukuda, Nakamura, & Takano, 2005). Yang and Lester (1994) found that DR to be the most powerful predictor of homicide rates. A study on Estonia, Latvia, and Lithuania covering the period 1993 to 2000, by Ceccato (2008), showed that social structure indicators such as

DR, more strongly predict the variations in 2000's CR than other indicators, such as land use and economic covariates. In Japan, the annual suicide rates correlated significantly with the annual unemployment rates and divorce rates. In Australia on the other hand, the annual suicide rates did not correlate with the annual unemployment and divorce rates (Inoue, Fujita, & Sakuta, 2008). Amato (2011) concluded that when the sample is divided into time periods, unemployment is negatively and significantly associated with divorce for the years following 1980 in US. These findings agree with the “cost of divorce” argument and suggest that high rates of unemployment reduce rates of divorce. Tarkiainen, Martikainen, and Laaksonen (2012) stated that socio-demographic characteristics in Finland including level of education, social class, employment status, and living alone explained much of the mortality disparity between income quintiles.

Using multilevel Poisson regression model, Chandola (2012) concluded that as cities in the developing world get richer, there is a risk that this leads to increasing spatial socioeconomic segregation of the poor within those cities. He stated that the spatial dimension of poverty within cities may be as important to health as poverty levels, where increasing spatial isolation of the poor tends to be associated with higher mortality rates. In Kurdistan, Iraq, Al-Windi (2011) stated that socio-demographic characteristics, such as marital status and occupation were associated to the prevalence of chronic diseases.

Very few studies tackled the concerns and the objectives of the current study in Jordan. For instance, AlQadi and Gharib (2012) tackled the issue of economic and social problems resulting from poverty of the disabled, specifically in southern-eastern regions. They found that social environment and place of residence were not significant in explaining poverty.

In the literature reviewed, in developing and developed countries, most researchers investigated three or less indicators. Most previous researches didn’t take into account the role of spatial location of the relationship between the socioeconomic and health indicators. To the authors’ best knowledge no study has investigated all the indicators together under investigation across Jordanian governorates. Briefly, the present study didn’t find significant global relationships between the indicators proposed in the study but several local relationships were found significant in some western governorates.

2 Materials and Methods

2.1 Data

Jordan was selected because of its importance in the Middle East region and the good quality data. Jordan has been facing several socioeconomic challenges, one of which is the large numbers of immigrants and refugees from neighbouring countries. The data on 12 governorates were obtained from the Jordan Statistical Yearbook (2012), based on the 2011 survey issued by Jordanian Statistics Leeô, Sang-il. “A Generalized Significance Testing Method for Global Measures of Spatial Association : an Extension of the Mantel Test” 36, no. 1967 (2004): 1687–1704. doi:10.1068/a34143.

were examined. These indicators were mortality rate (MR), divorce rate (DR), unemployment rate (UR), and crime rate (CR). The rate of the indicator for ith governorate was calculated as follows:

$$rate_i = (O_i / n_i)1000, \qquad i = 1,2,...,12$$

Where,

O_i = observed number of the indicator,

n_i = population size of the ith governorate.

Historically, in Jordan MR, UR, and CR decreased slightly from 3.6, 14.0, and 5.1 respectively in 2006 to 3.5, 12.9, and 5.0 in 2011. DR increased from 2.0 in 2006 to 2.6 in 2011. Figure 1 shows the study area and the spatial structure (neighbourhood scheme) and gives the name, identification number of each governorate and the ID of its boundary-sharing governorates.

Governorate	ID	ID Neighbours
Irbid	1	2,3,4,5
Ajlun	2	1,3,5
Jarash	3	1,2,4,5,6,7
Mafraq	4	1,3,6
Balqa	5	1,2,3,6,7,8
Zarqa	6	3,4,5,7
Amman	7	3,5,6,8,9,11
Madaba	8	5,7,9
Karak	9	7,8,10,11
Tafiela	10	9,11,12
Ma'an	11	7,9,10,12
Aqaba	12	10,11

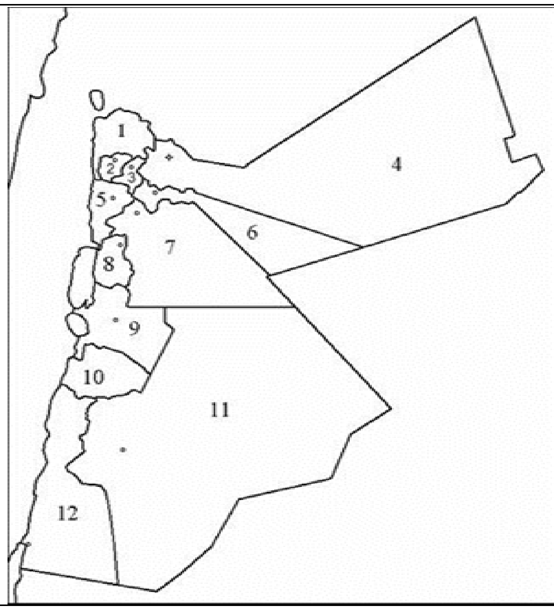

Figure 1: Shows the study area including all governorates with their IDs and the IDs of neighbouring governorates

2.2 Analysis

The research design was a multivariate cross-sectional analysis. Five steps of analysis were conducted. In step one the indicators were tested whether they follow a normal distribution using Kolmogorov-Smirnov test. They were found to follow approximately a normal distribution. Visual inspection of each indicator was shown in step two using mapping. Step three involved descriptive statistics for each indicator and calculating the classical Pearson correlation matrix between the indicators. In step four, global Lee's matrix of multivariate spatial association and its *p*-values were investigated based on a simulation study. The values of local Lee's matrix with its *p*-values for each governorate were investigated in the fifth step.

The correlation or interdependence of observations in neighbouring areas, however, posed a problem because governorates in close proximity were often more alike. It is, therefore, important to include the effects of spatial proximity when performing statistical inference on such processes. That explains the authors' application of the spatial measures. In the statistical analysis, SPLUS-Software was utilized in performing programs. Some of these programs are provided in the Appendix. The statistical analysis showed that these programs were highly efficient given the very huge data and the execution time. The authors contend that this is one of the paper's contributions.

2.2.1 Mapping

As the saying goes: picture is better than 1 000 words. Each indicator has a spatial structure that can be revealed by mapping. To construct a choropleth map, the data for governorates were grouped into four classes using quartiles. A gray tone was assigned for each class. Each indicator was categorized into four intervals using darker shades of gray to indicate increasing values. This approach allows qualitative evaluation of the spatial pattern. In the neighbourhood research, neighbours are defined as governorates which border each other or come within a certain distance of each other. In the current research neighbouring structure was defined as governorates sharing boundaries. The second order method (Queen Pattern) that included both the first-order neighbours (Rook Pattern) and those diagonally linked (Bishop Pattern) was used. Accordingly, maps showing the rates of mortality, unemployment, divorce, and crime in the Figures 2a, b, c, and d respectively explain visual inspection for each indicator.

Figure 2a, shows that MR is concentrated in the northern, western, and middle governorates; Figure 2b, shows that UR is concentrated in the western governorates; Figure 2c, shows that DR is concentrated in the middle and western governorates; and Figure 2d, shows that CR is concentrated in the eastern, middle, and southern governorates. It is seen that MR, DR, and CR are in general concentrated in the capital governorate, Amman, Eastern, and Southern

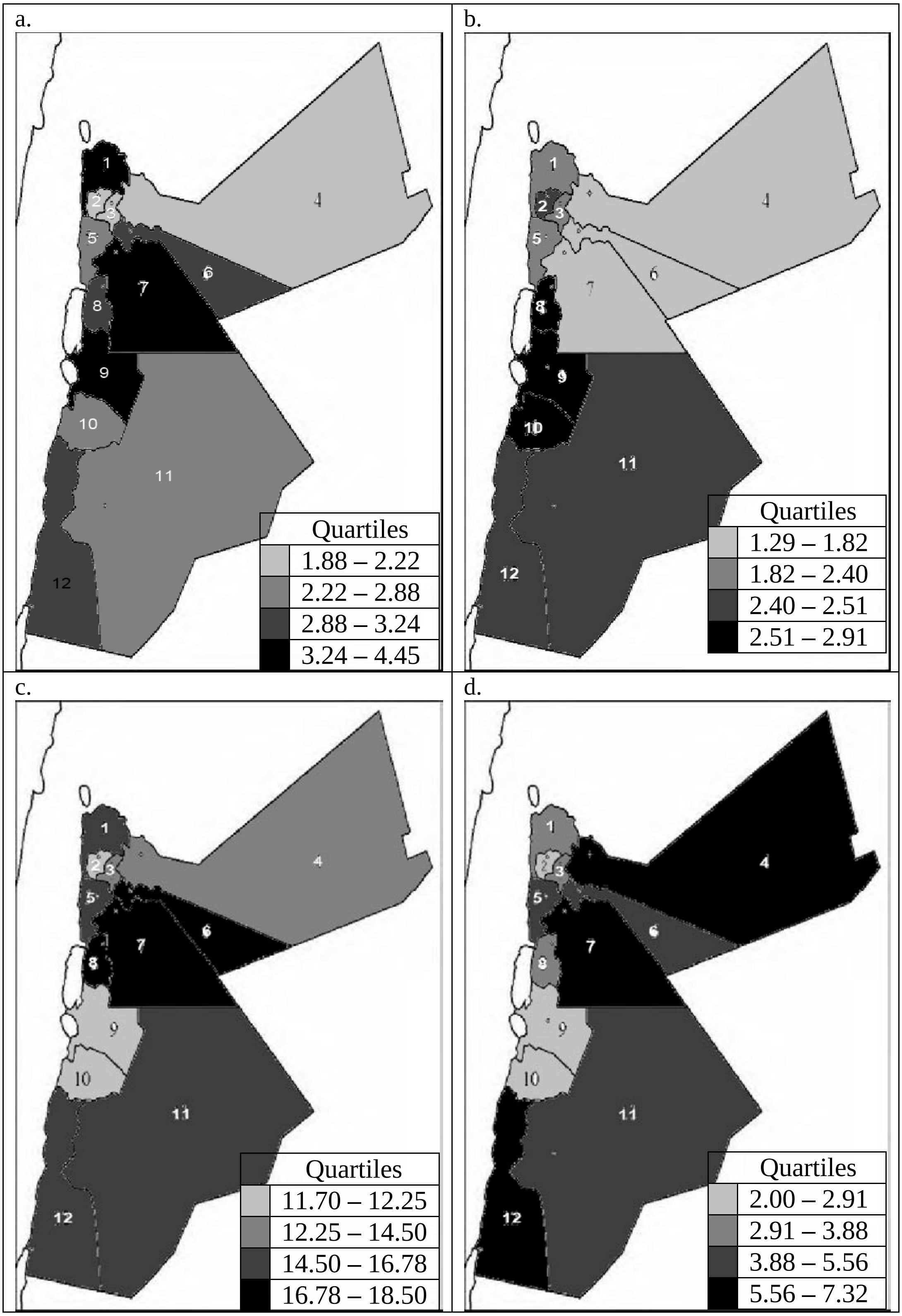

Figure 2: Shows the maps of a. MR, b. UR, c. DR, and d. CR

governorates. The UR in Amman is the lowest compared to other governorates due to higher job opportunities.

Although maps allow visual assessment of the spatial pattern, they have two important limitations: their interpretation varies from person to person, and there is the possibility that a perceived pattern is only coincidence or the result of randomness, and thus it is actually meaningless. For these reasons, it is more meaningful to compute a numerical measure of spatial pattern to find the multivariate spatial association that can be accomplished using spatial autocorrelation.

2.2.2 Global Multivariate Spatial Association

To find a global multivariate spatial association between two variables, Lee's matrix is applied (Lee, 2001):

$$\mathbf{L} = \frac{1}{N}\mathbf{Z}'(\mathbf{V}'\mathbf{V})\mathbf{Z},$$

Where,

$\mathbf{L}$ is a 4×4 variable-by-variable bivariate spatial association matrix,

$\mathbf{Z}$ is a 12×4 governorate-by-variable ($z-$scored) data matrix,

$\mathbf{V}$ is a 12×12 governorate-by-governorate spatial weight matrix (row-standardized: each element was divided by its row-sum),

$N = 12$ is the population size of governorates.

In matrix form the $\mathbf{L}$ can be represented as follows:

$$\mathbf{L} = \begin{bmatrix} L_{11} & L_{12} & L_{13} & L_{14} \\ & L_{22} & L_{23} & L_{24} \\ & & L_{33} & L_{34} \\ & & & L_{44} \end{bmatrix}_{(4\times 4)},$$

Where, the diagonal element L_{ii} has a particular meaning, which is the spatial smoothing scalar of the i th variable. It is given by:

$$L_{ii} = L_{X,X} = \frac{\sum_{i=1}^{N}(\tilde{x}_i - \bar{x})^2}{\sum_{i=1}^{N}(x_i - \bar{x})^2}, i = 1,\ldots,4,,$$

Where the spatial lag, $\tilde{x}_i = \sum_{j=1}^{N_i} w_{ij} x_j, i = 1,...,12$, and N_i is the number of neighbours of the i th governorate. The off-diagonal elements, $L_{ij} = L_{X,Y}$, represents a bivariate spatial association measure between two variables, largely determined by Pearson's correlation between two spatial lags vectors, that generates a smoothed version of Pearson's correlation coefficient between the original variables. It is given by:

$$L_{ij} = L_{X,Y} = \frac{\sum_{i=1}^{N}\left[\left(\sum_{j=1}^{N} v_{ij}(x_j - \bar{x})\right)\times\left(\sum_{j=1}^{N} v_{ij}(y_j - \bar{y})\right)\right]}{\sqrt{\left(\sum_{i=1}^{N}(x_i - \bar{x})^2\right)\left(\sum_{i=1}^{N}(y_i - \bar{y})^2\right)}}, i, j = 1, \ldots, 4, i \neq j ,$$

where

$$v_{ij} = w_{ij} \Big/ \sum_{j=1}^{N_i} w_{ij} , i, j = 1, 2, \ldots, 12,$$

and $w_{ij} = 1$ is the weight denoting the strength of the connection between two governorates i and j, otherwise, $w_{ij} = zero$, the row-standardized matrix, $\mathbf{V}$, can be represented, which is not symmetric, as follows:

$$\mathbf{V} = \begin{bmatrix} 0 & w_{1,2}\Big/\sum_{j=1}^{N_i} w_{1,j} & \cdots & w_{1,12}\Big/\sum_{j=1}^{N_i} w_{1,j} \\ w_{2,1}\Big/\sum_{j=1}^{N_i} w_{2,j} & 0 & \cdots & w_{2,12}\Big/\sum_{j=1}^{N_i} w_{2,j} \\ \vdots & \vdots & \ddots & \vdots \\ w_{12,1}\Big/\sum_{j=1}^{N_i} w_{12,j} & w_{12,2}\Big/\sum_{j=1}^{N_i} w_{12,j} & \cdots & 0 \end{bmatrix}_{(12\times12)} ,$$

and the $\mathbf{Z}$ can be represented as follows:

$$\mathbf{Z} = \begin{bmatrix} z_{11} & z_{12} & z_{13} & z_{14} \\ z_{21} & z_{22} & z_{23} & z_{24} \\ \vdots & \vdots & \vdots & \vdots \\ z_{12,1} & z_{12,2} & z_{12,3} & z_{12,4} \end{bmatrix}_{(12\times4)} ,$$

Where,

$$z_{ij} = \frac{y_{ij} - \mu_j}{\sigma_j}, i = 1, \ldots, 12, j = 1, \ldots, 4,$$

y_{ij} is the observed value in the i th governorate for the j th indicator,
μ_j and σ_j are the population mean and standard deviation of the j th indicator respectively.

The hypothesis under investigation suggests that there is a tendency for a certain type of spatial association to appear between two indicators, whereas the null hypothesis says that if this association is present, then it is a pure chance effect of observations in a random order. The analysis suggests an evidence of relationship between indicators only if the result of the global test is found significant; however it does not identify the location of any particular relationships. In addition to the relationship between two indicators that represents a global characteristic, the existence and the location of local spatial relationship is of interest in geographic sociology. Accordingly, local spatial statistic was advocated for identifying and assessing potential association between two indicators.

2.2.3 Local Multivariate Spatial Association

The matrix of the local multivariate spatial association developed in the present paper and based on the above global Lee's matrix, denoted as $\mathbf{L}_i$, can be shown as follows:

$$\mathbf{L}_i = \frac{1}{N_i^2}\mathbf{Z}_i'(\mathbf{v}_i\mathbf{v}_i')\mathbf{Z}_i, i = 1, 2, ..., 12$$

Where,

$\mathbf{L}_i$ is the 4×4 variable-by-variable bivariate spatial association matrix for the i th governorate,

$\mathbf{Z}_i$ is the $N_i \times 4$ i th governorate-by-variable (z-scored) data matrix,

N_i is the number of neighbours of the i th governorate,

$\mathbf{v}_i$ is the $i \times 12$ row-standardized vector (i th row in the above $\mathbf{V}$) of the i th governorate.

However, the $\mathbf{L}_i$ can be simplified to:

$$\mathbf{L}_i = \frac{1}{N_i^3}\mathbf{Z}_i'\mathbf{Z}_i, i = 1, 2, ..., 12$$

Where, for the i th governorate, $\mathbf{v}_i\mathbf{v}_i' = 1/N_i$. This definition is a special case where the spatial weight, w_{ij} is a binary (1,0) connectivity as explained above.

The local values of $\mathbf{L}_i$ indicate the relative contribution an individual governorate makes to the global values of $\mathbf{L}$. Also, the local value captures an observation's association with its neighbours in terms of the point-to-point association between the two indicators. Local statistic was investigated to test the null hypothesis of no spatial association.

2.2.4 Simulation Study

Real data are important for the development of statistical methods, and ideally their analysis also stimulates research in statistical theory. Simulated data is also important and have a different role. Simulated data is useful for validating the results of spatial analysis. Using Monte Carlo simulation, 9 999 random samples (12 values for each sample) were simulated. The process of simulation was conducted under the standard normal distribution to calculate the *p*-value for the bivariate association values of $\mathbf{L}$ and $\mathbf{L}_i$. When the word simulation is used, it refers to an analytical method meant to imitate a real-life system, especially when other analyses are too mathematically complex or too difficult to reproduce.

In the Monte Carlo testing, test statistic is calculated based on the data observed. Then the same statistic is calculated for a large number (say, *Nsimu*=9 999) of data sets, simulated independently under the null hypothesis of interest (e.g., simulated under complete spatial randomness). The proportion of test statistic values based on simulated data exceeding the value of a test statistic observed for the actual data set provides a Monte Carlo estimate of the upper-tail or lower-tail *p*-value for one sided hypothesis test (Waller & Gotway, 2004). Specifically, suppose that $L_{xy\,(obs)}$ denotes the test statistic for the data observed and $L_{xy\,(1)} \geq L_{xy\,(2)} \geq \cdots \geq L_{xy\,(Nsimu)}$ denote the test statistic values (ordered from largest to smallest) for the simulated data set. If $L_{xy\,(1)} \geq L_{xy\,(2)} \geq \cdots \geq L_{xy\,(l)} \geq L_{xy\,(obs)} > L_{xy\,(l+1)}$ (i.e., only the l largest test statistic values based on simulated data exceed $L_{xy\,(obs)}$), the estimated $p-\text{value}$ for the L_{xy} is given as follows:

$$p-\text{value} = \widehat{\Pr}(L_{xy} \geq L_{xy\,(obs)} \,|\, \text{H}_0 \text{ is true}) = \frac{l}{Nsimu+1},$$

where one is added to the denominator since the estimate is based on ($Nsimu+1$) values of $(\{L_{xy\,(1)}, \ldots, L_{xy\,(Nsimu)}, L_{xy\,(obs)}\})$. While the results were specific to these data, the case study helps identify general concepts for future study.

3 Results

Table 1 shows the descriptive statistics for each indicator. The highest rate and the largest variation were in the unemployment indicator which ranged from a minimum of 11.7 in Amman to a maximum of 18.5 in Madaba. But, the lowest rate and the smallest variation were in the divorce indicator which ranged from a minimum of 1.29 in Ajlun to a maximum of 2.91 in Zarqa. To assess the non-spatial association between these indicators a classical statistic, the Pearson correlation coefficient, was estimated. The values of Pearson correlation matrix and their $p-$values are shown in Table 2. Correlation significance was assessed at the .05 level. Two correlations were found significant: between MR and DR and between DR and CR. Table 3 shows the values of global Lee's matrix, $\mathbf{L}$ with their $p-$values in two parentheses. All values are found not significant. Table 4 shows the values of local $\mathbf{L}_i$ and their $p-$values in two parentheses for each governorate, where the $p-$values in boldface are considered significant at .05 level.

Table 1: Shows descriptive statistics, round it to two digits, for each indicator

Indicators	Mean	S.D	Skewness	Kurtosis	Minimum	Maximum
MR	2.84	.70	.79	1.52	1.88	4.45
DR	2.23	.51	-.62	-.44	1.29	2.91
UR	14.49	2.31	.47	-.91	11.70	18.50
CR	4.16	1.75	.76	-.40	2.00	7.32

Table 2: Shows Pearson correlation matrix and its $p-$values in two parentheses, where the $p-$value in boldface is considered significant at .05 level

Indicators	MR	DR	UR	CR
MR	1	.58 (**.047**)	-.03 (.921)	.40 (.202)
DR		1	-.47 (.123)	.70 (**.011**)
UR			1	-.48 (.119)
CR				1

Table 3: Shows global Lee's matrix, $\mathbf{L}$, and its $p-$values in two parentheses

Indicators	MR	DR	UR	CR
MR	.23	.06 (.220)	.10 (.114)	.08 (.162)
DR		.08	-.06 (.218)	.03 (.341)
UR			.28	-.02 (.398)
CR				.12

Table 4: Shows $\mathbf{L}_i$ matrices and its $p-$values in two parentheses for each governorate, where the $p-$value in boldface was considered significant at .05 level

Irbid

Indicator	MR	DR	UR	CR
MR	.07	.05 (.054)	.03 (.176)	.02 (.266)
DR		.06	<-.00 (.452)	.05 (.060)
UR			.02	-.02 (.270)
CR				.04

Ajlun

Indicator	MR	DR	UR	CR
MR	.07	.03 (.262)	<.00 (.481)	<.00 (.486)
DR		.02	<.00 (.497)	<.00 (.482)
UR			.03	.03 (.303)
CR				.02

Jarash

Indicator	MR	DR	UR	CR
MR	.04	.02 (**.008**)	-.01 (.175)	.02 (**.045**)
DR		.03	-.02 (.062)	.02 (**.029**)
UR			.02	-.01 (.122)
CR				0.03

Mafraq

Indicator	MR	DR	UR	CR
MR	.07	.04 (.233)	<-.00 (.479)	<.00 (.464)
DR		.08	-.05 (.177)	<.00 (.494)
UR			.07	.03 (.295)
CR				.02

Balqa

Indicator	MR	DR	UR	CR
MR	.04	.03 (**.001**)	-.01 (.204)	.02 (**.010**)
DR		.03	-.01 (.186)	.02 (**.039**)
UR			.03	-.01 (.222)
CR				.02

Zarqa

Indicator	MR	DR	UR	CR
MR	.12	.05 (**.041**)	-.02 (.272)	.05 (.052)
DR		.03	-.03 (.179)	.04 (.077)
UR			.05	-.05 (.056)
CR				.06

Amman

Indicator	MR	DR	UR	CR
MR	.01	<.00 (.386)	.01 (.178)	<-.00 (.483)
DR		.02	<-.00 (.324)	<.00 (.385)
UR			<.03	<-.01 (.316)
CR				<.00

Madaba

Indicator	MR	DR	UR	CR
MR	.21	.09 (.071)	-.08 (.096)	.12 (**.025**)
DR		.08	-.09 (.057)	.10 (.054)
UR			.11	-.10 (**.043**)
CR				.12

Karak

Indicator	MR	DR	UR	CR

Tafiela

Indicator	MR	DR	UR	CR

MR	.09	.06 (**.027**)	-.03 (.114)	.06 (**.020**)	MR	.01	-.02 (.376)	.03 (.304)	-.01 (.448)
DR		.07	-.04 (.107)	.06 (**.033**)	DR		.04	-.03 (.270)	.06 (.159)
UR			.10	-.06 (**.022**)	UR			.06	-.03 (.280)
CR				.06	CR				.14
Ma'an					Aqaba				
Indicator	MR	DR	UR	CR	Indicator	MR	DR	UR	CR
MR	.09	.04 (.064)	-.04 (.091)	.06 (**.025**)	MR	.01	.05 (.338)	-.04 (.361)	.04 (.367)
DR		.07	-.07 (**.011**)	.08 (**.004**)	DR		.29	-.22 (.084)	.21 (.086)
UR			.07	-.07 (**.014**)	UR			.22	-.19 (.104)
CR				.12	CR				.17

A significant correlation using Pearson coefficient is not reliable. The goal is to find the correlation taking into account the role of spatial proximity that is not considered in Pearson coefficient. However, due to the fact that neighbouring observations are interdependent, the Pearson correlation is overestimated compared to the Lee correlation. This upward estimate was obviously seen in the current study.

4 Discussion

Local spatial relationships between the indicators were not found significant in Irbid, Ajlun, Mafraq, Amman, Tafiela, and Aqaba. On the other hand they were found significant in Jarash, Balqa, Zarqa, Madaba, Karak, and Ma’an. The results imply that most socioeconomic indicators play an important role in explaining MR. Therefore, the government and policy makers in Jordan should give more attention to disadvantaged governorates. However, policies should be directed toward mortality reduction and mortality inequality, in particular in governorates facing socioeconomic difficulties. We were much careful in interpretation the results found in the current study. There are several confounding variables that are not accounted for in the analysis, because the necessary data were not available;

therefore it is potentially dangerous to draw strong conclusions from the associations found in the present study.

The authors noticed that the results in previous studies were not conclusive. Socioeconomic characteristics have been associated with deteriorating health in several but not all studies. The differences among studies could be explained by variations in the size of study area, spatial units, etc. Anselin (1995) stated that local pattern of spatial association was in line with global pattern. This is not necessarily the case. It is quite possible that the local association is an aberration that the global measure could not pick up; or it may be that a few local associations run in the opposite direction of the global spatial trend. Additionally, measurement errors in the indicators under investigation have probably biased findings toward the null. Local values that are very different from the mean (or median) would indicate locations which contribute more than their expected share to the global statistic. These could be outliers or high leverage points and thus would invite closer scouting. The present paper finds this to be the case. Although, global associations were not found significant, several local associations were found significant. Significant associations were found between CR and DR in Jarash, Balqa, Karak, and Ma’an; between MR and DR in Jarash, Balqa, Zarqa, and Karak; between MR and CR in Jarash, Balqa, Madaba, Karak, and Ma’an; between DR and UR in Ma’an; and between CR and UR in Madaba, Karak, and Ma’an.

The positive and significant relationship between CR and DR means that, divorce could make individuals confused, unstable, and violent which lead to crime. Higher CR could lead to social unrest including family conflicts which in turn result in higher DR. Stolzenberg and D'Alessio (2007) found a strong positive effect of DRs on spouse and ex-spouse victimization.

The positive and significant relationship between MR and DR results from psychological factors which may lead to increase in suicidal attempts or unwise and abnormal behaviour. High MR was found among young men and women with lower education, the unemployed, and those living without partners (Remes and Martikainen, 2012). A positive and significant relationship was found between MR and CR. Higher criminal behavior leads to death among criminals, whether by accident or as a result of a death sentence in the courts.

The current paper found a negative and significant relationship between UR and CR. This was unexpected compared to findings of previous studies, for example, Lin (2008) and Britt (1994), found a positive relationship. The negative relationship is explained as follows: higher crime rates mean criminals lose their jobs allowing more job opportunities to the unemployed, and thereby, leading to a decline in UR. This result coincides with the finding of Phillips and Land (2012) computed in US counties, stating that contemporaneous unemployment reduces crime-the unemployed find distraction in internet browsing, Facebook chatting, etc..

Finally, an unexpected negative and significant relationship between DR and UR was also found in Ma’an governorate. This result agrees with Amato (2011) who reached to the same conclusion. The higher the divorce rates, the more divorced women seek jobs to cover the cost of living which, in turn, leads to a decrease in UR. Citizens' access to health services reduces the risk of mortality. The proximity of residents to health centers facilitates using them. In Jordan private health services are expensive and thought to be of better quality compared to public health services. It is assumed therefore that private health services reduce mortality risk. Most health facilities are located in the capital governorate, Amman which is far from the disadvantaged governorates.

Having a job with a good pay is likely to reduce the chances or incentives to turn to criminal activities (Hirschi, 1969). It has also been argued that having a criminal record makes it harder for an individual to obtain and hold a good job (Leiberg, 1967). However, there are personal qualities that increase the likelihood of an individual turning to crime and becoming unemployed (Thornberry & Christenson, 1984). Vanagunas (1984) examined the association between crime and unemployment from a regional perspective in 24 US urban areas for the period 1974-1975. He found significant association between UR among minority males and motor vehicle theft and commercial robbery; and between UR among all males and commercial robbery. The findings of the present study do not agree with these findings. The relationship between UR and CR was found inverse and significant in three governorates: Madaba, Karak, and Ma'an. This means that criminals consider their criminal activities to be a profession, and drop out of the labour force reducing UR. Findings of the present study are at variance with some studies concerning the positive association between UR and CR, and between DR and UR, where these studies excluded the spatial effect. Although, official crime statistics in several countries showed that unemployed people have high crime rates and that communities with high unemployment experience rising rates of crime, the current study found a significant negative relationship between UR and CR in some governorates.

Finally, the problems unveiled by this study cannot be overcome by short-run actions; long-run efforts are needed to tackle spatial correlations across governorates. A time horizon is needed to allow the economy to create more job opportunities and to start new projects especially in the disadvantaged governorates.

Associations between indicators were not found the same in all governorates – spatial differences were obvious. Why do these differences exist? It is difficult to give clear answer due to social and statistical concerns. The answer could be one or more of the following. First, the tribe/ashira original Jordanians descend from. Each tribe constitutes a separate identity. An individual member of the tribe is loyal to his tribe and particularly to his 'sheikh'. The degree of internal cohesion and, therefore, the extent to which they are able to act collectively varies from one tribe to another. There is rivalry among tribes in their quest to acquire power, economic and political gains. Success in this rivalry depends on the relationships the tribes keep with the government (Gov. UK., 2007). Second, residents in Jordan form a complex mosaic. There are original Jordanians, 3 million Jordanians come from a Palestinian origin (UNCHR, 2008), and there are Egyptians, Iraqis, and recently Syrians. Not to mention small minorities from Bangladesh, Sri Lanka, etc., where these are house-maids. Tribes and other sorts of residents are clustered in different governorates. For example, a large number of Jordanians from a Palestinian origin are clustered in Amman and Zarqa; i.e., they are not equally distributed across governorates. Finally, measurement errors could exist and affect the results.

The geographic location of the problem is now clear. Efforts should be made to educate the public about the labour market requirements of various specializations and occupations in the coming years. This should help students make better choices and help design training courses to overcome unemployment. The authors agree with the suggestions made by Amerah (1993) about government policies in Jordan to alleviate unemployment inequalities, including activating the role of public health institutions and promoting better coordination among them. The authors call, as well, for improving the public sector procedures with regard to the recruitment of qualified staff, and establishing a national information data base to include data and information related the various aspects of Jordanian labour market. Amman witnessed the lowest UR, where job opportunities are more available compared to other governorates. In most governorates, the weak association between MR and UR was found inverse and not significant. This finding agrees with the study by Pick and Butler (1998) which stated that the standardized total mortality rate was only in simple correlations associated inversely with underemployment in the Mexican states.

5 Conclusions

First, based on visual inspection, the MR was concentrated in the northern, western, and middle governorates; the UR was concentrated in the western governorates; the DR was concentrated in the middle and western governorates; and the CR was concentrated in the eastern, middle, and southern governorates. Second, global spatial relationship was not found significant between the indicators under investigation but several local relationships were found significant in several western governorates. Third, in general mortality appears to be influenced by the divorce and crime in some governorates. Finally, in general crime was found to be influenced by divorce and unemployment. This is consistent with the findings of previous studies, given the differences in the environment, social structure, etc. The socioeconomically disadvantaged governorates face poor health services as represented by high MR.

6 Recommendations

Although the present paper could not study all spatial relationships between mortality and socioeconomic indicators, it was possible to highlight important issues raised in social and public health analyses. One of the main recommendations is to focus on creating social programs and services for the unemployed, the divorced and criminals for the purpose of improving their living conditions and their families and consequently their communities. Adopting government and private training strategies corresponding to the needs of the labour market can create employment opportunities which could turn disadvantage groups into productive forces.

The present study submits the following policy suggestions. Firstly, attracting and starting large scale investments to create new jobs and reduce UR. Secondly, education programs must meet the needs of the employers. It is important to reduce the brain drain of qualified personnel. At present, a huge number of young, highly educated people migrate to other countries especially Gulf Cooperation Council countries. Major public institutions, including educational institutions, government agencies, public hospitals, and other agencies, should increase their employment capacities and work with decision makers to improve absorption capacities of the labour markets. Thirdly, the government should review wage laws in all governorates especially the disadvantaged, to encourage migrant worker to return home. Fourthly, the government should, in terms of counseling, provide greater support to the social sectors. Finally, Jordan witnesses a domestic migration from small governorates to work in a big governorate like Amman in search for better paying jobs. To face this trend, the government can help reduce UR in small governorates by creating more employment opportunities and implementing policies to reduce disparities across all governorates. Further studies are needed regarding the spatial association between these and other socioeconomic indicators in developing countries and further studies should be conducted periodically in light of changing socioeconomic and political conditions.

Appendix

Program 1: Finding global Lee's matrix

```
module(spatial)
grid <- cbind(neighbor.weight$row.id, neighbor.weight$col.id,
neighbor.weight$weight)
dat <- cbind(data$MR, data$DR, data$UR, data$CR)
lee <- function(dat,grid)
{dd <- dim(dat)[1]
        mn <- colMeans(dat)
        st <- colStdevs(dat)
        mat <- (dat - kronecker(rep(1,dd),t(mn))) / kronecker(rep(1,dd),t(st))
        w <- matrix(0, nrow=dd, ncol=dd)
        for(i in 1:dim(grid)[1])
                w[grid[i,1], grid[i,2]] <- grid[i,3]
        wsum <- kronecker(t(rep(1,dd)), SDF1$nnghb)
                        wetl <- w / wsum
                        lee <- (1/dd) * (t(mat) %*% (t(wetl) %*% wetl) %*% mat)
lee
}
```

Program 2: Finding *p*-value of Lee measure

```
module(spatial)
s <- 9999
N <- 12
d <- 4
lmrdr <- vector(mode="numeric", length=s)
lmrur <- vector(mode="numeric", length=s)
lmrcr <- vector(mode="numeric", length=s)
ldrur <- vector(mode="numeric", length=s)
ldrcr <- vector(mode="numeric", length=s)
lurcr <- vector(mode="numeric", length=s)
set.seed(1000000)
gndata <- function()
{mat <- rmvnorm(N, mean=rep(0,d), sd=rep(1,d))
  mat
}
grid <- cbind(neighbor.weight$row.id, neighbor.weight$col.id,
neighbor.weight$weight)
leematrix <- function(dat,grid)
{dd <- dim(dat)[1]
        mn <- colMeans(dat)
        st <- colStdevs(dat)
        mat <- (dat - kronecker(rep(1,dd),t(mn))) / kronecker(rep(1,dd),t(st))
        w <- matrix(0, nrow=dd, ncol=dd)
        for(i in 1:dim(grid)[1])
                w[grid[i,1], grid[i,2]] <- grid[i,3]
        wsum <- kronecker(t(rep(1,dd)), SDF1$nnghb)
                        wetl <- w / wsum
                        lee <- (1/dd) * (t(mat) %*% (t(wetl) %*% wetl) %*% mat)
lee
}
for(t in 1:s)
    {le <- leematrix(gndata(),grid)
      lmrdr[t] <- le[1,2]
      lmrur[t] <- le[1,3]
      lmrcr[t] <- le[1,4]
      ldrur[t] <- le[2,3]
      ldrcr[t] <- le[2,4]
      lurcr[t] <- le[3,4]
    }
so <- cbind(sort(lmrdr),sort(lmrur),sort(lmrcr),sort(ldrur),sort(ldrcr),sort(lurcr))
count <- function(calculated,k)
{if (calculated > 0) for(j in 1:s)
```

```
                                        if(calculated <= so[j,k]) {count1 <-
s-j+1

break

}
                                        else count1 <- 0
  else                          for(j in 1:s)
                                        if(calculated <= so[j,k]) {count1 <-
j

break

}
                                        else count1 <- 0
  count1
}
pvalue <-
c(count(0.06,1)/(s+1),count(0.10,2)/(s+1),count(0.08,3)/(s+1),count(-0.06,4)/(s+1)
,count(0.03,5)/(s+1),count(-0.02,6)/(s+1))
```

Program 3: Finding *p*-value of Lee measure for the ith governorate

```
module(spatial)
s <- 9999
p <- 4
N <- 12
n <- 12
set.seed(1000000)
gndata <- function()
{mat <- rmvnorm(N, mean=rep(0,p), sd=rep(1,p))
 mat
}
leematrix <- function(dt,i)
{mn <- colMeans(dt)
     st <- colStdevs(dt)
     dd <- SDF1$nnghb[i]
     mat <- (datat(dt,i) - kronecker(rep(1,dd),t(mn))) / kronecker(rep(1,dd),t(st))
     leei <- (1/SDF1$nnghb[i]^3) * (t(mat) %*% mat)
 leei
}
datat <- function(dt,i)
{dattt <- matrix(nrow=SDF1$nnghb[i], ncol=p)
      for(k in 1:SDF1$nnghb[i])
           for(j in 1:p)
               dattt[k,j] <- dt[SDF1[i,k+1],j]
 dattt
}
simulated <- function(i)
{lmrdr <- vector(mode="numeric", length=s)
    lmrur <- vector(mode="numeric", length=s)
    lmrcr <- vector(mode="numeric", length=s)
    ldrur <- vector(mode="numeric", length=s)
    ldrcr <- vector(mode="numeric", length=s)
    lurcr <- vector(mode="numeric", length=s)
    for(t in 1:s)
      {gnda <- gndata()
        ll <- leematrix(gnda,i)
        lmrdr[t] <- ll[1,2]
       lmrur[t] <- ll[1,3]
       lmrcr[t] <- ll[1,4]
       ldrur[t] <- ll[2,3]
       ldrcr[t] <- ll[2,4]
       lurcr[t] <- ll[3,4]
      }
```

```
      so <-
cbind(sort(lmrdr),sort(lmrur),sort(lmrcr),sort(ldrur),sort(ldrcr),sort(lurcr))
  so
}
count <- function(calculated,k,i)
{sim <- simulated(i)
      if (calculated > 0) for(j in 1:s)
                    if(calculated <= sim[j,k]) {count1 <- s-j+1
                                             break
                                            }
                    else count1 <- 0
      else            for(j in 1:s)
                    if(calculated <= sim[j,k]) {count1 <- j
                                             break
                                            }
                    else count1 <- 0
  count1
}
dat <- cbind(data$MR, data$DR, data$UR, data$CR)
lee <- function(dat,i)
{mn <- colMeans(dat)
      st <- colStdevs(dat)
      dd <- SDF1$nnghb[i]
      mat <- (datt(i) - kronecker(rep(1,dd),t(mn))) / kronecker(rep(1,dd),t(st))
       leei <- (1/SDF1$nnghb[i]^3) * (t(mat) %*% mat)
  leei
}
datt <- function(i)
{dattt <- matrix(nrow=SDF1$nnghb[i], ncol=p)
        for(k in 1:SDF1$nnghb[i])
              for(j in 1:p)
                   dattt[k,j] <- dat[SDF1[i,k+1],j]
  dattt
}
for(i in 1:n)
     {le <- lee(dat,i)
      pvalue <-
c(count(le[1,2],1,i)/(s+1),count(le[1,3],2,i)/(s+1),count(le[1,4],3,i)/(s+1),count(le[
2,3],4,i)/(s+1),count(le[2,4],5,i)/(s+1),count(le[3,4],6,i)/(s+1))
      if(i==1)    pvalueall <- pvalue
       else         pvalueall <- cbind(pvalueall , pvalue)
     }
```

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