

Research Article

The Relationship between Health and Household Economic Status Using Spatial Measures in Iraq, 2004

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This study addresses spatial effects by applying spatial analysis in studying whether household economic status (HES) is related to health across governorates in Iraq. The aim is to assess variation in health and whether this variation is accounted for by variation in HES. A spatial univariate and bivariate autocorrelation measures were applied to cross-sectional data from census conducted in 2004. The hypothesis of spatial clustering for HES was confirmed by a positive global Moran's I of 0.28 with $P = 0.010$, while for health was not confirmed by a negative global Moran's I of -0.03 . Based on local Moran's I_i , two and seven significant clusters in health and in HES were found respectively. Bivariate spatial correlation between health and HES wasn't found significant ($I_{xy} = -0.08$) with $P = 0.80$. In conclusion, geographical variation was found in each of health and HES. Based on visual inspection, the patterns formed by governorates with lowest health and those with lowest HES were partly identical. However, this study cannot support the hypothesis that variation in HES may spatially explain variation in health. Further research is needed to understand mechanisms underlying the influence of neighbourhood context.

1. Introduction

The economic status hypothesis proposes that HES in a community or population influences health because unfavorable comparisons lead to families with a lower position to experience negative emotions that cause stress and detrimentally impact health, and well-being, and individuals with different statuses are less likely to develop trust and cohesion with one another. These processes are important for individual and family health, and also because their results may detract from community level social resources. Research on neighborhoods and health is motivated by the idea that we live in places that represent more than physical locations. They are also the manifestation of the social, cultural, political, and geographic cleavages that shape a constellation of risks and resources. Research on neighborhood effects has reconnected public health with its earlier population foundations, showing that the social ecology and built environments are important "upstream" determinants of chronic and infectious disease.

The HES is most influenced and is more expressive of the deterioration of Iraq's economic conditions throughout

the cities and rural areas and was heavily affected by the new developments during the year of survey and the years before. AL-Rubiay and AL-Rubaiy [1] studied the distribution of skin diseases in Basrah governorate, southern area in Iraq. They found that skin diseases are major problems in the community especially in those of low socioeconomic status. Their finding is consistent with what found in this paper, where Basrah was found as hot cluster in both health and HES.

Low socioeconomic status (SES), measured in low educational attainment and household income, are consistently related to greater disease severity, poorer lung function, and greater physical functional limitations in cross-sectional analysis [2]. The study of Arku et al. [3] investigated the relationship between housing and self-reported general and mental health in Ghana, where they found that housing conditions, demand and control residents have to where they live, emerged as significant predictors of self-reported general and mental health status. A \$10 000 increase in income increased the odds of better self-rated health by 10% for those with two or more chronic conditions [4]. Allender et al. [5] concluded that rich wards surrounded by poor

areas have higher coronary heart disease (CHD) mortality rates than rich wards surrounded by rich areas, and poor wards surrounded by rich areas have worse CHD mortality rates than poor wards surrounded by poor areas. Bassanesi [6] stated that within Brazilian cities, the disadvantaged social groups are spatially segregated, where this segregation is bad for the health of poor districts and good for the health of the rich districts. This process of segregation leading to divergent health outcomes depending on the socioeconomic profile of communities may intensify health inequalities. In Indian cities where the poor are more isolated in their neighbourhoods have higher mortality rates than cities where the poor are less isolated; whereas cities where the poor are clustered into fewer neighbourhoods have lower mortality rates than cities where the poor are more evenly spread out [7].

People of lower socioeconomic position face significant communication challenges which may negatively impact their health [8]. In South Korea, Jung-Choi et al. [9] found graded inverse association between income and mortality for most but not all, specific causes of death. The results of Fors et al. [10] showed that income inequalities were associated with mortality. As stated by Charloite et al. [11], chronic illnesses (CI) are one of the indicators that measure children's health, where their results in Denmark and Sweden were children in families with one or both parents without paid work had an increased prevalence of recurrent psychosomatic symptoms, and Bambra [12] showed that the relationship between work, worklessness, and health inequalities were influenced by the broader political and economic context in the form of welfare state regimes. High levels of household crowding and poor social, economic and environmental conditions in many Australian communities appear to place major constraints on the potential for building programs to impact on the occurrence of common childhood illness [13]. In all countries, rich and poor, there is an unequal distribution of health both within countries and within cities [14].

2. Materials and Methods

2.1. Data. The data were collected from Iraq household socioeconomic survey, based on census conducted in 2004. For each of ($N = 18$) governorate, health and HES data were applied. The percentage data of HES includes indicators of the financial position of the household, work, ownership, and the household's assessment of their overall economic status. The percentage data of health field includes indicators of child health, reproductive health, and chronic diseases as well as the time needed to reach a health center and the level of satisfaction with health services.

2.2. Analysis. Data analysis involved five steps. In step 1, the health and HES data are tested for normal distribution, where they were found to follow approximately normal distribution. In step 2, visual inspection based on the quantified gradients for each of health and HES data using quartiles were conducted. Step 3 included the calculation of global

Moran's I for each of health and HES variables to detect the global clustering and also the significance of I -statistic using permutation test for each variable was examined. Step 4 involved the calculation of local Moran's I_i for i th governorate and its P value using Monte Carlo simulation to detect the local clusters for health and HES. In step 5, using quartiles, visual inspection of local Moran's values for each variable was inspected based on choropleth mapping.

The health and HES data were categorized into four intervals. These intervals were used for all maps using lighter shades of gray to indicate increasing values of health and HES. Such approach enables qualitative evaluation of spatial pattern. In the neighbourhood researches, neighbours may be defined as governorates which border each other or within a certain distance of each other. In this paper, neighbouring structure was defined as governorates which share a boundary. The *second-order* method (queen pattern) which included both the first-order neighbours (rook pattern) and those diagonally linked (bishop pattern) was used. A neighbourhood system was given in Figure 1, where ID neighbour for each governorate was shown. Although maps allow us to visually assess spatial pattern, they have two important limitations: their interpretation varies from person to person, and there is the possibility that a perceived pattern is actually the result of chance factors, and thus not meaningful. For these reasons, it makes sense to compute a numerical measure of spatial pattern, which can be accomplished using spatial autocorrelation. Therefore, global spatial clustering and local spatial clusters were identified.

2.2.1. Identification of Global Spatial Clustering. The goal of a global index of spatial autocorrelation is to summarize the degree to which similar observations tend to occur near each other in geographic space. In this exploratory spatial analysis, the spatial autocorrelation using standard normal deviate (z -value) of Moran's I under normal assumption was tested. Moran's I is a coefficient used to measure the strength of spatial autocorrelation in regional data. The interpretation of the Moran's statistic is as follows. If $I > E(I)$, then a governorate tends to be connected to the governorates that have similar attribute values and vice versa. Global clustering test was used to determine whether clustering was existed throughout the study area, without determining statistical significance of local clusters. Moran's I is calculated as follows [15]:

$$I = \frac{N \sum_{i=1}^N \sum_{j=1}^N w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{S_0 \sum_{i=1}^N (x_i - \bar{x})^2}, \quad i \neq j, \quad (1)$$

$$S_0 = \sum_{i=1}^N \sum_{j=1}^N w_{ij},$$

where $N = 18$ is the number of governorates, $w_{ij} = 1$ is a weight denoting the strength of the connection between two governorates i and j that shared a boundary; otherwise, $w_{ij} = 0$, x_i and x_j represent the health or HES in i th and j th governorate, respectively. The autocorrelation coefficient can be used to test the null hypothesis of no



FIGURE 1: Study area shows all governorates with their IDs and the neighbours of each governorate.

spatial autocorrelation or spatially independent versus the alternative of positive spatial autocorrelation:

$$\begin{aligned} H_0 &: \text{no clustering exists (no spatial autocorrelation);} \\ H_1 &: \text{clustering exists (positive spatial autocorrelation).} \end{aligned} \quad (2)$$

A significant positive value of Moran's I indicates positive spatial autocorrelation, showing the overall pattern for the governorates having a high/low level of health or HES similar to their neighbouring governorates. To test the significance of global Moran's I , z -statistic which follows a standard normal distribution was applied. It was calculated as follows [16]:

$$z = \frac{I - E(I)}{\sqrt{\text{var}(I)}}. \quad (3)$$

Permutation test was used. What a permutation test tells us is that a certain pattern in data was or was not likely to have arisen by chance. The observations of each health and HES were randomly reallocated 1000 times with 1000 spatial autocorrelations calculated in each time to test the null hypothesis of randomness. That is to say, the hypothesis under investigation suggests that there will be a tendency for

a certain type of spatial pattern to appear in data, whereas the null hypothesis says that if this pattern was present, then this was a purely chance effect of observations in a random order. The analysis suggests an evidence of clustering if the result of the global test is significant, but it does not identify the locations of any particular clusters. Besides, the existence and location of localized spatial clusters in the study population are of interest in geographic sociology. Accordingly, local spatial statistic was advocated for identifying and assessing potential clusters.

2.2.2. Identification of Local Spatial Clusters. A global index can suggest *clustering* but cannot identify individual *clusters* [17]. Anselin [18] proposed the local Moran's I_i statistic to test the local autocorrelation, where local spatial clusters, may be identified as those locations or sets of contiguous locations for which the local Moran's I_i was significant.

Clusters may be due to aggregations of high values, aggregations of low values, or aggregations of moderate values. Thereby, high value of I_i statistic suggests cluster of similar (but not necessarily large) values across several governorates, and low value of I_i suggests an outlying cluster in a single governorate i (being different from most or all

of its neighbours). A positive local Moran's value indicates local stability, such as governorate that has high/low health surrounded by governorate that has high/low health. A negative local Moran's value indicates local instability, such as governorate has low health surrounded by governorate has high health or vice versa. However, each governorate's I_i value can be mapped to provide insight into the location of governorates with comparatively high or low local association with its neighbouring values.

Anselin stated that the indication of local patterns of spatial association may be in line with a global indication although this is not necessarily the case. It is quite possible that the local pattern is an aberration that the global indicator would not pick up, or it may be that a few local patterns run in the opposite direction. Thereby, this is what found for health variable, where global Moran's I of health was found not significant, but some local clusters of high health were found significant. However, Moran's I_i for i th governorate may be defined as [17]:

$$I_i = \frac{(x_i - \bar{x})}{S} \sum_{j=1}^N \left[\left(\frac{w_{ij}}{\sum_{j=1}^{N_i} w_{ij}} \right) \frac{(x_j - \bar{x})}{S} \right], \quad i = 1, 2, \dots, 18, \quad (4)$$

where, analogous to the global Moran's I , the x_i and x_j represents the health or HES in i th and j th governorate, respectively, N_i is the number of neighbours for i th governorate, and S is the standard deviation. It was noteworthy that the number of neighbours for i th governorate were taken into account in I_i statistic by the amount: $(w_{ij}/\sum_{j=1}^{N_i} w_{ij})$, where w_{ij} was measured in the same manner as in Moran's I statistic. Local Moran's statistic was used to test the null hypothesis of *no clusters*. However, local Moran's statistic is a decomposition of global Moran's I into the contributions of small areas. In the statistical analysis, all programs performed in S + 8 Software.

2.2.3. Bivariate Spatial Association. So far, only univariate spatial association is presented that quantifies the spatial structure of one variable at a time. There is much discussion about what is an appropriate measure for bivariate spatial association. However, spatial dependence or spatial clustering causes losing in the information that each observation carries. When N observations are made on a variable that is spatially dependent (and that dependence is positive so that nearby values tend to be similar), the amount of information carried by the sample is less than the amount of information that would be carried if the N observations are independent because a certain amount of the information carried by each observation is duplicated by other observations in the cluster. A general consequence of this is that the sampling variance of statistics is underestimated. As the level of spatial dependence increases the underestimation increases. The problem is that when spatial autocorrelation is present, the variance of the sampling distribution of, for example, Pearson's correlation coefficient, which is a function of the number of pairs of observations, is underestimated. Spatial autocorrelation

coefficient can be modified to estimate the bivariate spatial correlation between two variables [19]:

$$I_{xy} = \frac{1}{S_0} \frac{\sum_{i=1}^N \sum_{j=1}^N w_{ij} (x_i - \bar{x})(y_j - \bar{y})}{\left[\sqrt{\sum_{i=1}^N (x_i - \bar{x})^2 / N} \right] \left[\sqrt{\sum_{j=1}^N (y_j - \bar{y})^2 / N} \right]}, \quad (5)$$

where x and y are the health and HES variables, respectively. Although the mathematics is quite straightforward, very few software packages offer the option of computing I_{xy} . Thus, programming was used to find I_{xy} . To test the significance of I_{xy} , z -statistic was applied: $z = I_{xy} \sqrt{N - 1}$, which follows approximately standard normal distribution.

3. Results

Descriptive analyses were performed to assess the demographic characteristics of data set. The mean and standard deviations for health were found 22.30 and 6.91, respectively; skewness and kurtosis were found -0.40 and -0.46 , respectively. The five-number summary of health data consists of the minimum, maximum, and quartiles written in increasing order: Min = 7.60, $Q_1 = 16.95$, $Q_2 = 22.80$, $Q_3 = 27.73$, and Max = 32.70. From the five-number summary, the variations of the four quarters were found 9.35, 5.85, 4.93, and 4.97, respectively, where the first quarter has the greatest variation of all. Also, descriptive statistics were calculated for HES, where the mean and standard deviations were found 56.19 and 9.17, respectively; skewness and kurtosis were found 0.86 and 1.51 respectively. The five-number summary of HES data set was found: Min = 42.80, $Q_1 = 48.85$, $Q_2 = 56.05$, $Q_3 = 62.63$, and Max = 80.40. From the five-number summary, the variations of the four quarters were found 6.05, 7.2, 6.58, and 17.77, respectively, where the fourth quarter has the greatest variation of all.

Basrah governorate accounted for the lowest health (7.60%). It was followed by the governorates Missan and Erbil, which accounted for (12.4%) and (15.7%), respectively. The highest rate was in the governorate of Suleimaniya with (32.7%). This can be explained by the persistent growth of economic activity in most fields, which provide more job opportunities, and this will lead to better levels of health. Kirkuk governorate accounted for the lowest HES (42.8%). It was followed by Erbil and Diala governorates which accounted for (43.9%) and (47.1%), respectively. The highest HES was found in the governorate AL-Muthanna with (80.4%). Figure 1 shows the study area explaining all governorates with their identification numbers (IDs).

Maps can display geographical inequality across governorates of Iraq. Since local Moran's I_i vary by location, it is easier to interpret it visually by color coding. Figures 2(a), 2(b), 2(c), and 2(d) show visual insight for health, and its local Moran's values, HES and its local Moran's values respectively, with darkest shade corresponding to lowest quartile. Based on visual inspection, an overall worsening pattern (lower scores) for health was found in northern, central, and eastern-southern governorates, such as 4, 5, 6, and 18. The suggestion of global clustering for health was not confirmed by a negative global Moran's I of -0.03 with

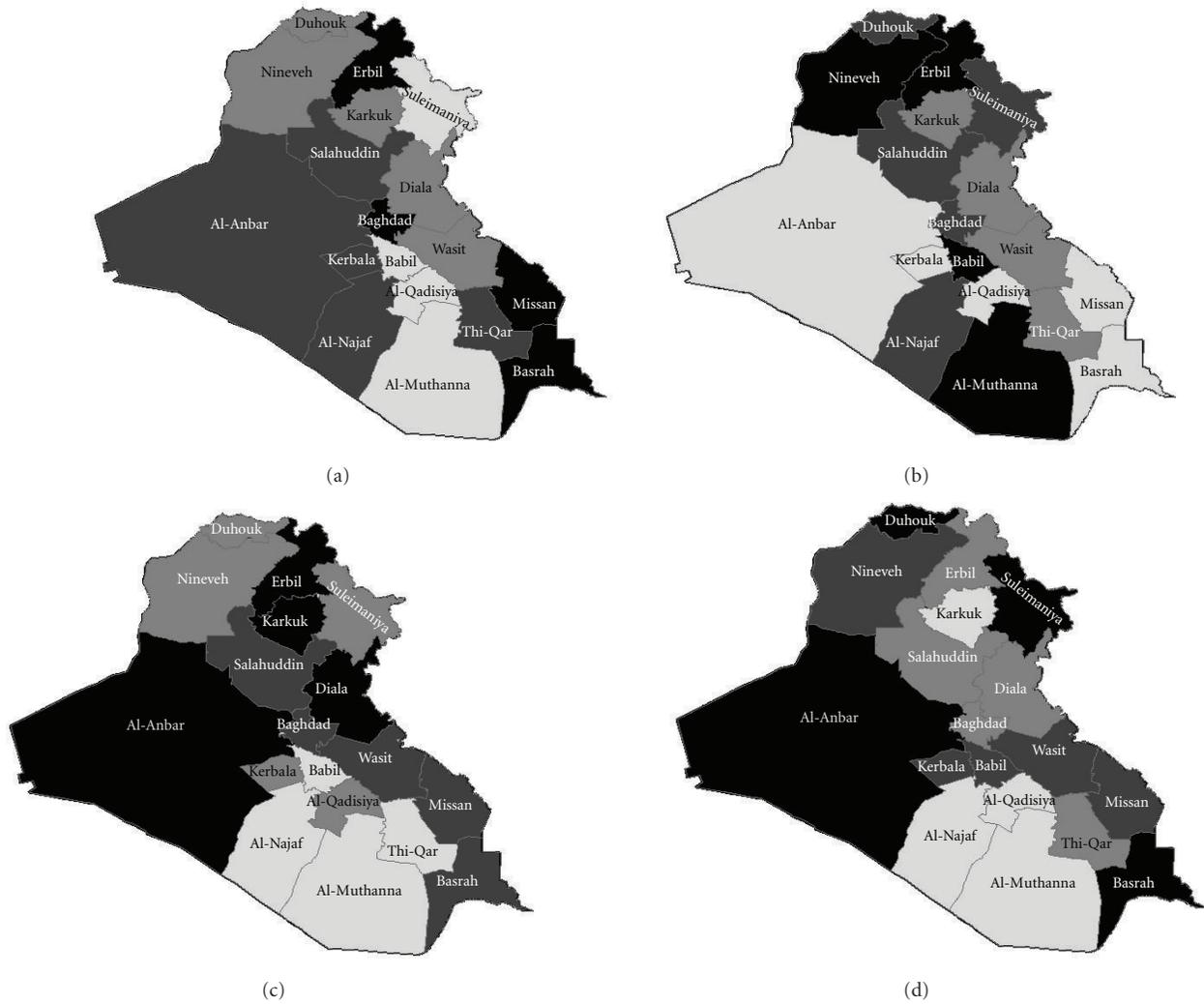


FIGURE 2: Choropleth maps show (a) health variable, (b) local Moran's values of health variable, (c) HES variable, and (d) local Moran's values of HES variable.

an associated $z = 0.20$ and $P = 0.840$; but confirmed with some local significant clusters of high health. Also, based on visual inspection, an overall worsening pattern (lower scores) for HES was found in the northern, western, and eastern-southern governorates, such as 1, 3, 7, and 18. The suggestion of global clustering for HES was confirmed by a positive global Moran's I of 0.28 with an associated $z = 2.57$ and $P = 0.010$.

To investigate global clustering, permutation test was done, where the permutation P value = 0.394 for health was found not significant; while permutation P value = 0.011 for HES was found significant. Thus, the null hypothesis of no spatial autocorrelation was not rejected for health but rejected for HES. The results of local Moran's I_i values for health and HES and their P values are reported in Table 1. Two significant clusters of high levels of health were found (14 and 17) as shown from their P values. The local significant clusters of high level of health in some governorates such as 14 and 17 could probably be contributed by the high level of HES in these governorates,

in some of their neighbours such as governorate 16, and/or by the HES inequality among their neighbours as shown in Figures 2(b) and 2(d). For HES, seven significant clusters were found (4, 5, 6, 12, 13, 14, and 15) as shown from their P -values.

Pearson's correlation coefficient between health and HES was found (0.38), which is not significant with ($P = 0.115$). Bivariate spatial correlation between health and HES was found ($I_{xy} = -0.08$) which is not significant with ($z = -0.33$ and $P = 0.80$). However, although both results were not significant, it is seen that Pearson coefficient is always over estimated when used in finding the spatial correlation. That is why, in investigating bivariate spatial correlation, it is recommended to use Wartenberg's [19] measure.

4. Discussion

The spatial association between spatial pattern of health and spatial pattern of HES was examined, allowing for the

TABLE 1: Shows both health (%) and HES (%), Local Moran's I_i values for health and HES, and their corresponding P values.

ID	Health	I_i for health	P value	HES	I_i for HES	P value
1	25.80	-.12	.625	58.90	-.18	.674
2	25.60	-.22	.761	57.20	-.07	.614
3	32.70	-.05	.578	57.90	-.21	.738
4	27.60	-.03	.548	42.80	.92	.026
5	15.70	-.49	.903	43.90	.43	.062
6	27.30	.04	.363	47.10	.38	.098
7	17.10	.07	.265	48.10	-.19	.767
8	16.50	-.09	.648	54.20	.11	.240
9	29.60	-.20	.766	63.80	.02	.377
10	19.40	.07	.308	58.10	.04	.352
11	23.80	.01	.401	49.10	-.11	.677
12	17.60	-.09	.654	49.50	.48	.021
13	21.10	-.07	.610	66.30	.77	.013
14	28.10	.40	.066	62.60	.63	.024
15	31.70	-.52	.896	80.40	1.50	.001
16	21.80	.02	.398	62.70	.31	.104
17	12.40	.95	.024	54.90	.01	.428
18	7.60	.10	.301	54.00	-.26	.753

effects of neighbouring governorates that share the boundary with a particular governorate. Findings allow policy makers to better identify what types of resources are needed and precisely where they should be employed. The rationale behind the relationship between health and HES is that people who live in or have a low level of HES usually suffer from financial strain that could lead to health problems for themselves and for their families.

After rejecting the null hypothesis, it becomes possible to conclude that there is some form of clustering, and it is of course of interest to know the exact nature of the clustering process. Is it only global type clustering or are there hot spot clusters? If the later, how many hot spots are there, and where are they located? In the analysis of the association between health and HES, exploratory tools are used such as descriptive tables and small-area choropleth mapping. Geographical distributions of health and HES were examined visually using maps.

The first wave of studies on neighbourhoods and health focused on showing the relevance of neighbourhoods and the effects beyond individual socioeconomic characteristics. These studies argued that neighbourhoods influence health by behavioral patterns such as collective socialization, peer-group influence, and institutional capacity. The second wave of the studies evaluated these mechanisms with latent measures of neighbourhood characteristics, such as level of segregation, collective social, and economic capacity [20]. However, health inequalities can only be reduced substantially if governorates have a democratic mandate to make the necessary policy changes, if demonstrably effective policies can be developed, and if these policies are implemented on the scale needed to reach the overall targets [21].

The HES may be associated with health reflecting the existing of individual income which provides good medical

care, high quality of food, and acceptable household conditions. The usual correlation coefficients, such as Pearson coefficient, only test whether there is an association between two attributes by comparing values at the same location. Map comparison involves more than pairwise comparison between data recorded at the same locations as spatial units were arbitrary subdivisions of the study region and people could move around from one area to another and could be affected by HES levels in areas other than the area they live in, that is, the level of health in i th governorate was thought to be influenced by the levels of HES not just in i th governorate but also in neighbouring governorates. Neighbourhood residential turnover had been linked to poor child development, problem behavior, and health risks [22].

Permutation distribution can be used to test the significance of the global Moran's statistic. For this purpose, 1000 random permutations were applied. Simulated data is useful for validating the results of bivariate spatial analysis. However, using Monte Carlo simulation, 9999 random samples were simulated, 18 values for each sample, for each of health and HES. These samples (9999 matrices, each have two columns, one for health and the other for HES) were generated under bivariate standard normal distribution.

Whilst correlation obviously does not automatically imply any causation, there are two possibilities. First, low HES could cause low levels of health or second vice versa. Epidemiologic evidence suggests that the direction of causation from HES to health has a greater possibility than the converse (low health causes low HES). Although more research can be done to elucidate mechanisms and mediating factors, the present author found sufficient evidence to recommend that intervention research, to determine ways to reduce the adverse effect of HES on health. HES may exert detrimental effects on health through many mechanisms:

(1) by disrupting community and personal social relationships [23], (2) by leading to greater risk behavior, such as alcohol consumption and poor diet [24], (3) by causing stress [25], and (4) by precipitating reaction, like that caused by other losses [23]. It did not assess the evidence for any particular mechanism or series of mechanisms since the main purpose in this study was to assess whether, not how, HES pattern is related to the pattern of health.

5. Conclusions

This study reports on the use of a particular form of spatial autocorrelation to group governorates according to how similar or dissimilar their health and HES are relative to surrounding areas. Exact causal mechanisms are not known but possibly include correlated health and HES. The findings support the common wisdom in the public health research domain that worsening pattern of health is more densely distributed in the areas where people have lower levels of HES. Findings, demonstrated that when health is associated with HES, thereby suggesting policies that improve HES growth may yield health returns. However, there is a possibility that a check of additional alternatives and a focus on other aggregate variables would have led to another conclusions.

Although, it cannot provide a causal relationship between health and HES, the results were conclusive in at least five aspects: First, based on mapping, low level of health was concentrated along the north-south axis, for instance in the governorates (5, 12, 7, 8, 17, and 18). Low HES was concentrated along the north-south axis, for instance, in the governorates (4, 5, 6, 7, 17, and 18). Based on *visual* inspection, the patterns formed by those governorates with lowest health and those with lowest HES were in general identical. Second, several governorates were not observed visually as hot spots for both health and HES, but after considering the information of their neighbours (i.e., calculating local Moran's I_i values), the pattern of hot spots, for example, governorates (9 and 15) for health, and governorates (1 and 9) for HES can obviously be seen. Third, based on global Moran's index, the clustering tendency showed that HES for each governorate can be spatially correlated with HES in neighbouring governorates, while the clustering tendency in health was not found significant. Fourth, the significance of bivariate spatial correlation did not support the hypothesis that the spatial patterns of health and HES can be associated. Fifth, governorates which possess neighbours with high degree of inequality in health seem to show higher inequality in HES, for instance governorates (4 and 8). This was consistent with what Haining [26] stated, the levels of such variable in area i was thought to be influenced by the levels of another variable not just in area i but also in its neighbouring areas. This supports the hypothesis that the degree of variations in HES between these governorates and their neighbours could somewhat influence health. Global spatial pattern for health field was not found but some local clusters of high level of health were found in the southern part. Global spatial pattern for HES was found and several

local clusters of high level of HES were found in eastern-northern and western-southern parts.

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