Association between Spatial Patterns of Acute Malnutrition and Household Income in Iraq-2004

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Abstract

In this research acute malnutrition (AM) and household income (HI) are investigated. Historically, governorates of Iraq suffered inequality in AM and HI for several reasons, such as government's focus on heart of city in specific governorates; like Baghdad, Basra, and Nineveh. Question is raised whether the spatial patterns of AM and HI are existed in Iraq? If so, can the pattern of HI explain the pattern of AM?

The present paper investigates the spatial structure of AM across different governorates in Iraq and its spatial correlation to HI. This investigation will provide implications for policy makers, finding local clusters and showing visual picture for each of AM and HI.

The study utilizes a cross-sectional survey data collected in 2004 for 18 governorates. Mapping is used as the first step to conduct visual inspection for AM and HI using quartiles. Several spatial econometric techniques are available in the literature, which deal with the spatial autocorrelation in geographically referenced data. Two statistics of spatial autocorrelation, based on sharing boundary neighbours, known as global and local Moran's I, are carried out. Wartenberg's measure is used to detect bivariate spatial correlation.

In conclusion, based on visual inspection of mapping, global clustering in high level of AM and low level of HI were in general concentrated in western-southern governorates. This global clustering for AM was confirmed by significant global Moran's I statistic, but was not confirmed for HI. Out of 18 governorates, three and one governorates were found as local clusters in AM and HI respectively based on local Moran's I_i. Bivariate spatial correlation between AM and HI was not found significant.

Keywords: Spatial autocorrelation, Acute malnutrition, Household income, Mapping, Moran measure, Iraq

1. Introduction

Areas, independent of their geographic level of aggregation, are known to be interrelated partly due to their relative locations. Similar economic performance among areas can be attributed to proximity. Consequently, a proper understanding and accounting of spatial liaisons are needed in order to effectively forecast regional economic variables. Acute malnutrition (AM) and household income (HI) were studied in many developed and some developing countries using different statistical measures. We have developed a framework to better understand how AM and HI are spatially associated across governorates of Iraq. Martin et al. (2011) examined how poverty and education influence adolescent overweight. They found that family poverty and parental education do not predict adolescent overweight. Janjua, Iqbal, and Mahmood (2001) assessed the relationship between socioeconomic position (SEP) and under- and over-nutrition in Pakistan using multinomial regression based on cross-sectional data in 2006. They didn't find significant association between SEP and underweight.

The relationship between malnutrition and socioeconomic indicators was studied by several authors in many countries. Based on demographic and health survey 2004 to 2006, Urke, Bull, and Mittelmark (2011) investigated the association of parents socioeconomic status (SES) using parental education, occupation, and household wealth index, with malnutrition using the indicator child stunting in Peruvian Andes and in Peru nationally. In both samples, SES was significantly related to stunting. Subramanyam et al. (2011) assessed the association between changes in state per capita income and the risk of under-nutrition among children in India. They applied logistic models that accounted for the clustering of data and they didn't find consistent evidence that economic growth leads to reduction in childhood under-nutrition. Magalhães et al. (2011) estimated geographical risk profile of anemia accounting for malnutrition, malaria, and helminth infections in Burkina Faso, Ghana, and Mali in 2003-2006. They found malnutrition and parasites make to anemia. In Kenya, The high prevalence of chronic malnutrition suggested that stunting is a sustained problem within this urban informal settlement, not specifically resulting from the relatively brief political crisis (Burke et al., 2011). As stated by Filho, Kawachi, and Gotlieb (2012), income inequality is associated with worse population health in Sõ Paulo, Brazil. One of malnutrition reasons is the deprivation from basic requirements of life. There is greater variation in death rates and socio-demographic characteristics among the most deprived constituencies in Britain. Socio-demographic factors that are most strongly correlated with death rates among the most deprived places differ from areas of all deprivation levels and include population density, ethnicity and migration (Tunstall et al., 2011).

Twenty-five years ago, Iraq had the best living standard comparing to its neighbours. In the last years, Iraq was fallen due to some indicators. In some cases, was fallen far behind. The growing income inequality was contributed significantly to the deprivation increasing in Iraq. By the beginning of 1980s, other factors contributed to the rise in disparities among some governorates. These factors include geographic location of governorate in terms of its proximity to battlefields, and social composition of governorate's population especially in north and south. In other governorates, disparities stemmed according to political and tribal origins. The ratios of AM at main regions, South, Baghdad, Center, and North, in 2004 were 2.5, 1.8, 1.4, and 1.2 respectively. Median total of HI (in Iraqi Dinar) at these main regions in 2004 were 105 500, 100 000, 100 000, and 129 081 respectively. In recent years, a growing interest has been seen in examining the existence of spatial autocorrelation of AM and its spatial relationship to several indicators such as HI, education, etc. Low wage flexibility and limited labour mobility involve persistent unemployment differentials across governorates of Iraq. Governorates are tightly linked by migration, commuting, and inter-governorate trade. These types of spatial interaction are exposed to the frictional effects of distance, possibly causing the spatial dependence of governorate labour market conditions.

To understand linkages between socioeconomic health indicators, investigation should focus on features of areas rather than on compositional characteristics of residents of area, which cannot fully describe the social environment in which people live (Macintyre, Maciver, & Sooman, 1993). So, the aim of the research is to investigate geographical mapping and spatial autocorrelation of AM and its spatial relationship to HI. Spatial autocorrelation is the term used for the interdependence of the values of lattice data over space. However, it was argued that lattice data are spatially correlated. Mapping plays an important role in monitoring health status of people. Maps can reveal spatial patterns that is neither recognized previously nor suspected from the examination of statistics table. It reveals high risk communities or problem areas (Lawson & Williams, 2001). The purpose of spatial analysis is to identify pattern in geographical data and then attempts to explain this pattern. Findings are expected to enhance health monitoring and policy interventions across governorates of Iraq.

The importance of this research objective emanates the studies conducted by Amaral et al., (2011) in Brazilian community and Burke et al., (2011) in sub-Saharan Africa. They stated that malnutrition represents the strongest risk factor for morbidity and mortality. Also, to author's knowledge, no previous studies used spatial analysis techniques and geographical mapping in studying spatial inequality in AM and HI in Iraq. The importance of mapping was stated by Koch (2005): why make the map if detailed statistical tables carry the same results? Perhaps the most important reason for studying spatial statistics is not only interested in answering the "how much" question, but the "how much is where" question (Schabenberger & Gotway, 2005). Therefore, the usefulness of the paper is to suggest where to intervene geographically. In light of these: (1) the existence of spatial global clustering, (2) spatial local clusters for each of AM and HI were investigated, (3) mapping was displayed for each of AM and HI and for their local Moran's values, and (4) bivariate spatial correlation between AM and HI was examined based on Wartenberg's (1985) statistic. Study design was a cross-sectional analysis in a survey conducted in Iraq in 2004.

The paper is structured as follows: Section one reviews the literature relating to AM and HI disparities generally in several countries and particularly in Iraq. Materials and methods including data and analysis are presented in the second Section. Third section explains the results with many details. Discussion is explained in fourth Section. Last section is closed with several conclusions.

2. Materials and Methods

2.1 Data

Data were collected from the ministry of planning and development cooperation (2005), based on a survey conducted at Iraq in 2004. For each of (N=18) governorates, transformed AM and HI data were applied. AM is a devastating public health problem of epidemic proportions. The prevalence of AM is now one of the most widely used indicators of the severity of humanitarian crises throughout the world. This is endorsed by a wide array of UN organizations, donors, national governments and international agencies. AM for male and female in Iraq in 2004 were approximately same as accounted 1.9 and 1.8 respectively. AM is measured as low weight for height. The individual's weight is compared to the 'normal' weight for that height. Normal weights for children are determined by studies that have weighed thousands of healthy children. Based on this information, World Health Organization (WHO) developed charts known as international standards for expected growth. If the weight is less than international standards, the individual is considered acutely malnourished. WHO created cut-off points to indicate the severity of malnutrition? If the individual's weight-for-height is less than -3 z-scores (or standard deviations) of normal, s/he suffers from severe acute malnutrition. The formula for calculating this index is given by:

z = (measured value - median of reference population) / standard deviation of the reference population

HI (in Iraqi Dinars) is measured as the median total of household income. Overall, households receive 45.3% of their income from wages and salaries; 25.0% from self-employment and employer income; 19.8% from property income; 5.2% from social payments; and 4.7% from "transfers". These percentages vary geographically. For example, wages and salaries account for 31.4% of household income in Al-Najaf but 56.7% in Basrah; self-employment and employer income account for 8.8% in Diala but 43.1% in Al-Najaf; and property income accounts for 14.2% in Al-Muthanna but 27.3% in Erbil.

2.2 Analysis

Data analysis involved six steps. In step 1, AM and HI variables were tested for normal distribution. Both variables aren't found to follow normal distribution. Therefore, both variables are transformed to follow normal distribution using LISREL software. LISREL scales normal scores so that transformed variable has the same sample mean and standard deviation as the original variable. Thus, normal score is a monotonic transformation of original score with same mean and standard deviation (this characteristic can be considered as an advantage in this transformation) but with values of skewness and kurtosis much reduced. In step 2, visual inspection based on quantified gradients for each of AM and HI was conducted using quartiles. Step 3 included the calculation of global Moran's -statistic for each of AM and HI to detect global clustering. Also, the significance of -statistic was examined using permutation test. Step 4 involved the calculation of local Moran's for governorate and it's -value using Monte Carlo simulation to detect local clusters for each of AM and HI. In step 5, visual inspection for local Moran values was inspected using choropleth mapping. In Step 6, bivariate spatial correlation between AM and HI was examined using Wartenberg's (1985) statistic.

Variables were categorized by four intervals. These intervals were used for all maps using darker shades of gray to indicate increasing values of studied variables. Such approach enables qualitative evaluation of spatial pattern. In neighbourhood researches, neighbours may be defined as areas border each other or within a certain distance of each other. In this research neighbouring structure was defined as governorates share a boundary. The *second order* method (queen pattern) that include both the first-order neighbours (rook pattern) and those diagonally linked (bishop pattern) was used. A neighbourhood structure of Iraq's governorates is explained in Figure 1, where the ID neighbours for each governorate are shown.

Although maps allow visual assessment for spatial pattern, they have two important limitations. First, their interpretation varies from person to person. Second, there is possibility that a perceived pattern is actually the result of randomness and thus not meaningful. For these reasons, it makes sense to compute a numerical measure for spatial pattern, which can accomplish using spatial autocorrelation measures.

2.2.1 Identification of Global Spatial Clustering

Moran's I coefficient was used to measure the strength of spatial autocorrelation. In this exploratory spatial analysis, the spatial autocorrelation was tested using standard normal deviate (z-value) of Moran's I under normal assumption. The null hypothesis of no spatial autocorrelation or spatially independent versus the alternative of positive spatial autocorrelation is as follows:

H_0 : No clustering exists (no spatial autocorrelation)
H_1 : Clustering exists (positive spatial autocorrelation)

Moran's I is calculated as follows (Cliff & Ord, 1981):

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

and

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

Where, $n = 18$ is the number of governorates, $w_{ij} = 1$ is a weight denoting the strength of the connection if the two governorates i and j shares a common boundary, otherwise, $w_{ij} = zero$, and x_i and x_j represent AM or HI in i*th* and j*th* governorate respectively.

A significant positive value of Moran's I indicates positive spatial autocorrelation, showing the overall pattern for governorates having a high/low level of AM or HI similar to their neighbouring governorates. A significant negative value indicates negative spatial autocorrelation, showing the governorates having a high/low level of AM or HI unlike their neighbouring governorates. To test the significance of global Moran's I, z-statistic which follows a standard normal distribution was applied. It is calculated as follows (Weeks, 1992):

$$z = \frac{I - E(I)}{\sqrt{var(I)}}$$

Permutation test was applied. A permutation test tells us that a certain pattern in data is or is not likely to have arisen by chance. The observations of AM or HI were randomly reallocated 1 000 times with 1 000 of spatial autocorrelations were calculated in each time to test the null hypothesis of randomness. 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 is present, then this is a pure chance effect of observations in a random order. Null hypothesis is: no pattern in the data.

The analysis suggests an evidence of clustering if the result of the global test is found significant; though it doesn't identify the location of any particular cluster. Besides clustering that represents global characteristic of AM or HI, the existence and location of localized spatial clusters 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* (Waller & Gotway, 2004). Anselin (1995) proposed local Moran's I_i statistic to test local autocorrelation. Local spatial clusters, sometimes referred to as hot spots, may be identified as those locations or sets of contiguous locations for which the local Moran's I_i is significant. Local Moran statistic was used to test the null hypothesis of no clusters. Moran's I_i for i*th* governorate may be defined by Waller and Gotway (2004) as:

$$I_i = \frac{(x_i - \bar{x})}{S} \sum_{j=1}^{N} \left(w_{ij} \middle/ \sum_{k=1}^{N_i} w_{ik} \right) \frac{(x_j - \bar{x})}{S}, \ i = 1, 2, ..., 18$$

Where, analogous to the global Moran's I, x_i and x_j represent the AM or HI in i*th* and j*th* governorate respectively, N = number of neighbours for i*th* governorate, and S is the standard deviation. It is noteworthy to mention that the number of neighbours for i*th* governorate was taken into account by the amount: $(w_{ij}/\sum_{k=1}^{N_i} w_{ik})$, where w_{ij} was measured in the same manner as in Moran's I statistic.

Cluster could be due to either aggregation of high values, aggregation of low values, or aggregation of moderate values. Thereby, high value of I_i suggests a cluster of similar (but not necessarily large) values across several governorates. 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 value indicates local stability, such as a governorate that has high/low value surrounded by governorate that has high/low value. A negative local Moran value indicates local instability, such as a governorate having low value surrounded by governorates having high value or vice versa. Each governorate's I_i value was mapped to provide insight into the location of governorates with comparatively high or low local association with their neighbouring values.

2.2.3 Bivariate Spatial Association

So far, only univariate spatial correlation is presented. It quantifies the spatial structure of one variable at a time. Rates of malnutrition on their own do not mean very much, unless the underlying related indicators of malnutrition are understood: i.e. whether a socioeconomic indicator such as HI is correlated with malnutrition? 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. Due to a certain amount of 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 prevails when spatial autocorrelation is present. The variance of sampling distribution of e.g. Pearson correlation coefficient, which is a function of number of pairs of observations, is underestimated. Spatial autocorrelation coefficient can be modified to estimate the bivariate spatial correlation between two variables (Wartenberg, 1985):

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

Where x and y are AM and HI 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. In statistical analysis, all programs were performed using $S + 8$ Software.

3. Results

Figure 1 shows the study area explaining all governorates with their identification numbers (ID). Figure 2a and b show visual insight for AM and HI respectively. Visual inspection shows that high level in AM was concentrated in western-southern governorates, particularly in governorates 9, 10, 14, and 15. While low level of HI was concentrated in northern and western-southern governorates, particularly in governorates 12, 13, 15, and 16. Several governorates are not observed visually as hot spots, such as 1, 2, and 4 in AM, and 7 and 18 in HI. But, after considering the information of their neighbours, i.e. calculating their local Moran values, the pattern of their hot spots can be obviously seen. Figure 3a and b show visual insight for local Moran values of AM and HI respectively. Darkest shade corresponds to the highest quartile. These maps display geographical inequalities across governorates of Iraq. Based on visual inspection for AM taken from Figure 2a, an overall worsening pattern (high scores) was found in eastern-southern parts. Based on visual inspection for HI taken from Figure 2b, an overall worsening pattern (low scores) was found in northern and eastern-southern parts.

The suggestion of spatial clustering in HI that results from a visual inspection of mapping was not confirmed by global Moran's I of .01 with an associated -statistic of .53 and $p = .593$. The suggestion of spatial clustering in AM that results from a visual inspection of mapping was confirmed by a positive slightly significant global Moran's I of .16 with an associated -statistic of 1.68 and $p = .092$. To investigate global clustering, permutation test was done. For AM, permutation $p = .051$ was found slightly significant, and for HI, permutation $p = .294$ was found not significant. Thus, the null hypothesis of no spatial autocorrelation was rejected for AM while for HI was not rejected. Three and one significant local clusters were found for AM (their ID are 12, 14, and 15) and HI (its ID is 15) respectively. Clusters of AM and HI are located, as shown in Figures 3a and b respectively, in northern and southern parts. Transformed AM and HI variables, their local Moran values, and their significant p-values in boldface are shown in Table 1.

Simulated data are useful for validating the results of spatial analysis. When the word simulation is used, it is referred to an analytical method meant to imitate a real-life system, especially when other analyses are too mathematically complex or too difficult to reproduce. However, using Monte Carlo simulation, 9 999 random samples, eighteen values for each sample, were simulated. The process of simulation was conducted under standard normal distribution to calculate p-values for local Moran values of AM and HI. While results are specific to these data the case study helps to identify general concepts for future studies.

The AM is influenced by several variables in various ways. Spatial relationship between AM and HI was investigated. Pearson correlation coefficient between AM and HI, that is not spatial measure, was found -.18. Pearson correlation was not found significant with $p = .243$. Bivariate spatial correlation between AM and HI was found ($I_{xy} = -.24$), that is not significant with $z = -.99$ and $p = 0.990$.

4. Discussion

This study aims to clarify how the risk of AM is spatially clustered and how is associated with HI across governorates of Iraq. The above framework revealed some noteworthy findings. Such findings allow policy makers to better identify what types of resources are needed and precisely where they should be employed across governorates. After rejecting the null hypothesis for AM, it becomes possible to state that there was a form of global clustering and it was, of course, of interest to know the exact nature of this clustering. Are there hot-spot clusters? If so, how many hot-spots are there? Where are they located?

Exploratory tools such as descriptive Table and somewhat small area choropleth maps were used. Maps provide powerful means to communicate data to others. Unlike information displayed in graphs, tables and charts; maps also provide bookmarks for memories. In this way, maps are not passive mechanism for presenting information. Usually, in the spatial analysis and geographical mapping, small spatial areas should be used such as districts, counties. . . etc. But, in this research governorates were used which are considered somewhat larger than for example districts due to data were not available for smaller areas. Most often the word 'neighbourhood' suggests a relatively small area surrounding individuals' homes. But researchers commonly make use of larger spatial area such as census tracts (Coulton et al., 2001). Often, choices about neighbourhood spatial definitions were made with respect to convenience and availability of contextual data rather than study purpose (Schaefer-McDaniel et al., 2009). Schaefer-McDaniel et al. stated that, researchers might utilize census data and thus rely on census-imposed boundaries to define neighbourhoods even though these spatial areas may not be the best geographic units for the study topic.

Although, this work was conducted as part of a wider study, its immediate implications are more for policy makers and practitioners than for researchers. This study adds to the global body of knowledge on the utilization of spatial analysis to strengthen the research–policy interface in the developing countries such as Iraq. The spatial pattern of high AM in Iraq was concentrated in old governorates such as AL-Muthana, Salahuddin, and AlQadisiya. This pattern was characterized by underprivileged living conditions. This was consistent with what found by Yuan, Fulong, and Xueqiang (2011) in the city of Guangzhou, China. Our contribution shows that the patterns of AM and HI are quite complicated. Also, Investigators should draw from different research strands to understand where and why socioeconomic indicators particularly HI could matter for AM. The findings of this study suggest that tackling AM is a high priority. There should be fostered efforts to ensure that malnutrition-prevention strategies include the poor governorates.

As noted by Waller and Jacques (1995), the test for spatial pattern employs alternative hypotheses of two types; the omnibus not the null hypothesis or more specific alternatives. Tests with specific alternatives include focused tests that are sensitive to monotonically decreasing risk as distance from a putative exposure source (the focus) increases. Acceptance of either types (the omnibus or a more specific alternatives) only demonstrates that some spatial pattern exist, and does not implicate a cause (Jacques, 2004). Hence, the existence of spatial pattern alone cannot demonstrate nor prove a causal mechanism.

It is very well known that employment is considered a major source for household income. Iraq faced specific challenges with regard to jobs in its state-owned enterprises. With over 500 000 workers on the payroll, state-owned enterprises were a major source of employment. Analysis of other episodes of conflict in Iraq indicates a very strong reciprocal relationship between the lack of security and high unemployment (World Bank, 2006). While reconstruction and associated public-sector jobs are important in the initial phase of Iraq's recovery, they will not create a sufficient number of jobs to meet the population's needs in the long term; even if recovery is on a massive scale. Researchers recommend designing global development strategies that focus on job creation and income generation. These strategies incorporate elements of basic social protection and social dialogue at the global and local levels as an attempt to reduce inequalities in AM and HI.

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. While measuring spatial correlation involves more than pair wise comparison between data recorded at the same locations as spatial units are arbitrary subdivisions of study region, people could move around from one area to another. People could be affected by the variation in HI and other socioeconomic indicators in areas other than the area they live in. i.e., AM inequality in ith governorate is thought to be influenced and explained by the inequality of HI and probably other socioeconomic variables not just in ith governorate but also in neighbouring governorates. However, the population size in these governorates is not equal; i.e. the rate of AM does not express the absolute size of the problem.

Anselin (1995) stated that indication of local pattern of spatial association may be in line with a global indication, although this is not necessarily be 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 of the global spatial trend. This case is found in this research. Local values that are very different from the mean (or median) would indicate locations that contribute more than their expected share to the global statistic. These may be outliers or high leverage points and thus would invite closer scouting. Although global clustering was not found significant for HI and was found slightly significant for AM, several local clusters were found significant in AM and HI.

The application of statistical techniques to spatial data faces an important challenge, as expressed in the first law of geography: "everything is related to everything else, but closer things are more related than distant things" (Tobler, 1979). The quantitative expression of this principal is the effect of *spatial dependence*, i.e. when the observed values are spatially clustered, the samples are not independent. Increasing in AM level in governorate generates increasing in AM level in governorate . This mechanism of transmission causes a spatial autocorrelation. The obvious question after finding significant clusters in AM is-why? Could this pattern associated by the spatial pattern of socioeconomic indicators such as HI or by the limitation of economic resources? However, further research is required regarding this bivariate spatial association between AM and other socioeconomic indicators. This research will be our interest in Iraq and other developing countries in the near future.

It should be emphasized that AM problem cannot overcome in the short-run, but long-term efforts are needed to tackle inequality across governorates. In turn, enabling the economy to create more job opportunities and establish new projects, especially in the governorates that found as hot spot clusters. It means that the place of the problem is now clearly shown. Health inequality is ubiquitous around the world. Thus, fresh perspective to tackle inequality is always welcomed by research community invested in reducing and eventually eliminating this inequality. Finally, this kind of studies should be conducted periodically in light of the changing of socioeconomic and political conditions.

5. Conclusions

Conclusions are comprehensive in at least five aspects. First, visual inspection shows that high level in AM was concentrated in western-southern governorates. While low level of HI was concentrated in northern and western-southern governorates. Second, several governorates are not observed visually as hot spots in am and HI. But, after considering the information of their neighbours, the pattern of their hot spots can be obviously seen. Third, global clustering in AM was found slightly significant but was not found significant in HI. Based on local Moran measure, three governorates were found to be significant local clusters in AM located in central and western-southern governorates. Only one significant local cluster in HI was found. The opposite being the case for those with low AM were in general seen in central and eastern governorates and those with high HI were seen in central and some southern governorates. Forth, from negative local Moran values, looking at the local variation, some governorates were represented as areas of dissimilarity in AM and in HI. Means that these governorates with low AM and/or HI surrounded by governorates with high AM and/or HI or vice versa. Fifth, spatial correlation between AM and HI was not found significant. This is consistent with what found by several studies. Martin et al. (2011) concluded that poverty status is not associated with overweight. Janjua, Iqbal, and Mahmood (2011) stated that no significant association found between SEP and underweight. Subramanyam et al. (2011) didn't find consistent evidence that economic growth leads to reduction in childhood under-nutrition.

Maps display geographical inequality in AM and HI across governorates of Iraq. The analytical approach used here delineates governorates of relatively high AM. This permits policy makers to develop strategies to minimize this inequality. Policy which pays attention to area characteristics will reduce the variation in AM and HI. Consequently this will improve prosperity which in turn improves population health. In summary, the study supports the hypothesis of a spatial clustering in AM at governorate level that probably reflects the inequality distribution in several socioeconomic indicators across governorates of Iraq. Researchers recommend that direct investments in appropriate health interventions may be necessary to reduce both AM level in each governorate and the variation across all governorates.

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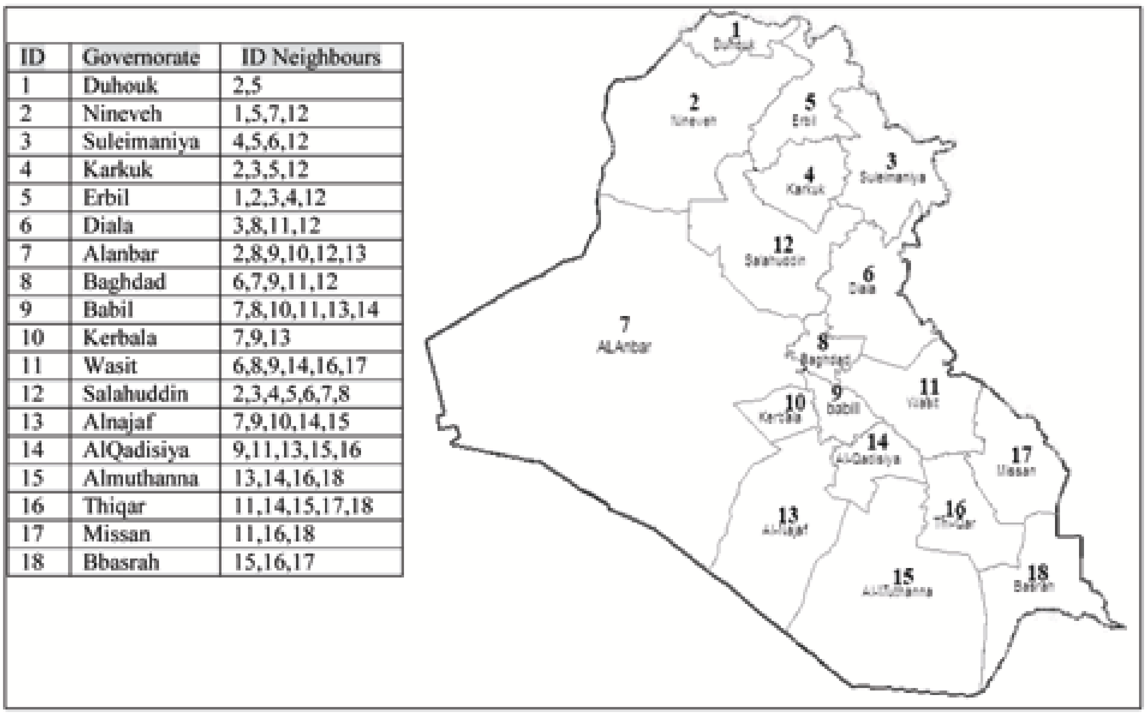
Table 1. Shows both transformed HI (Iraqi Dinars) and AM (%), local Moran's I_i values for transformed HI and AM, and their corresponding p-values (significant values in boldface at. 1 level)

ID	HI	I_i for HI	p-value	AM	I_i for AM	p-value
1	130688.32	.90	.056	.69	.44	.153
2	94859.43	-.47	.879	.69	.44	.082
3	118281.79	.03	.369	-.13	.37	.106
4	105361.23	-.03	.542	1.09	.61	.070
5	141569.82	-.03	.535	2.53	-.59	.929
6	100400.44	.07	.308	2.29	-.24	.770
7	121537.60	-.39	.884	1.92	.01	.421
8	102918.52	.02	.386	1.54	.00	.435
9	112740.78	-.04	.560	2.90	.29	.085
10	110222.71	.00	.465	3.14	.08	.306
11	107779.99	-.01	.470	1.54	-.26	.816
12	82452.91	-.43	.915	1.28	.36	**.044**
13	87700.21	.23	.144	1.92	-.07	.610
14	97743.74	.35	.083	4.12	.79	**.011**
15	71571.41	.95	**.011**	3.46	.73	**.025**
16	91603.63	.14	.212	2.29	.20	.168
17	125441.02	-.10	.627	2.71	-.05	.568
18	115397.48	-.29	.775	1.92	-.05	.571



ID	Governorate	ID Neighbours
1	Duhouk	2,5
2	Nineveh	1,5,7,12
3	Suleimaniya	4,5,6,12
4	Karkuk	2,3,5,12
5	Erbil	1,2,3,4,12
6	Diala	3,8,11,12
7	Alanbar	2,8,9,10,12,13
8	Baghdad	6,7,9,11,12
9	Babil	7,8,10,11,13,14
10	Kerbala	7,9,13
11	Wasit	6,8,9,14,16,17
12	Salahuddin	2,3,4,5,6,7,8
13	Alnajaf	7,9,10,14,15
14	AlQadisiya	9,11,13,15,16
15	Almuthanna	13,14,16,18
16	Thiqar	11,14,15,17,18
17	Missan	11,16,18
18	Bbasrah	15,16,17

Figure 1. Study area shows all governorates with their ID and the neighbours of each governorate

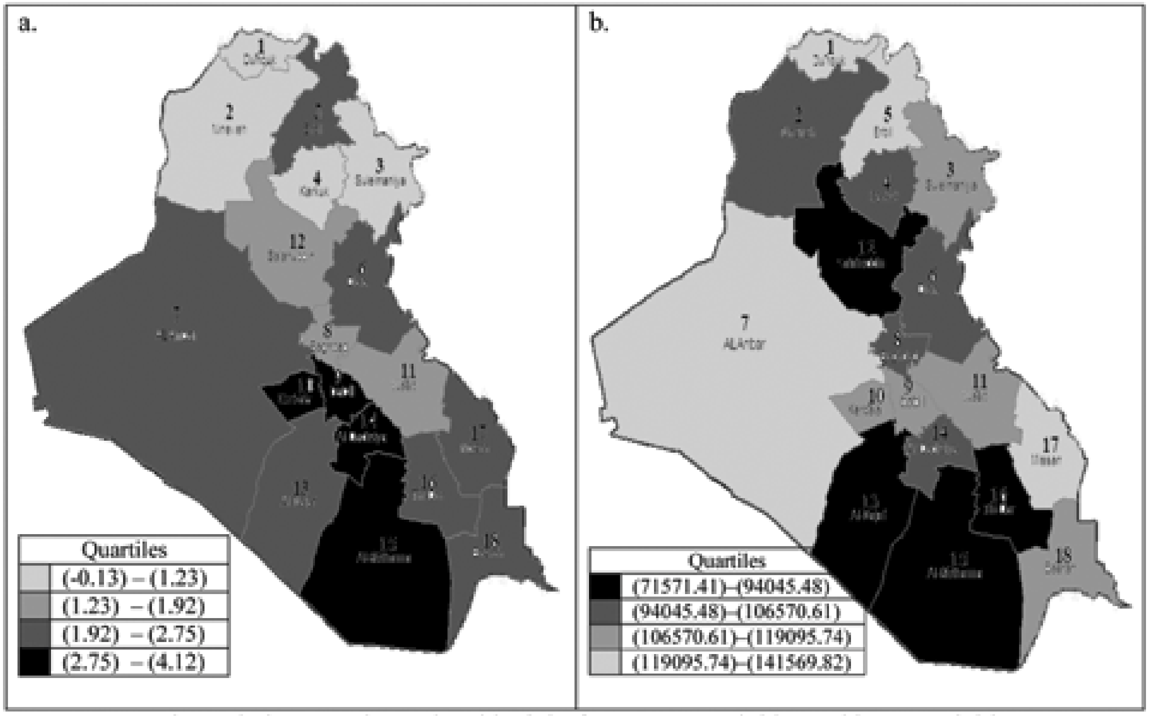


Figure 2. Choropleth maps show visual insight for: a. AM variable, and b. HI variable

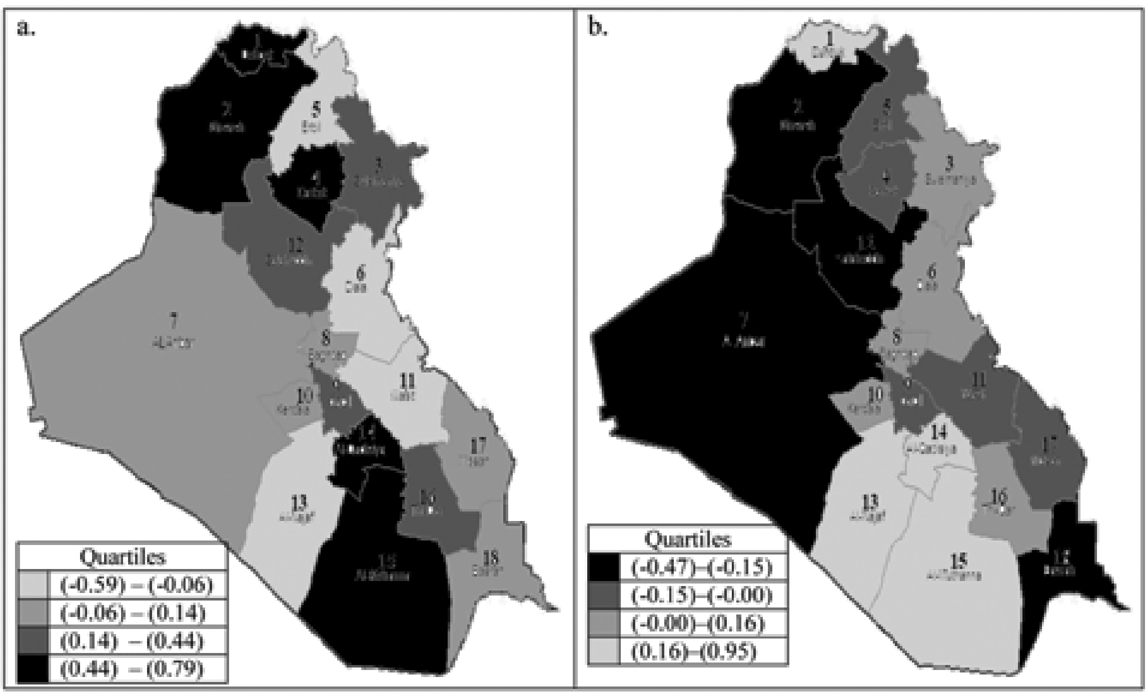


Figure 3. Choropleth maps show visual insight for local Moran values of: a. AM and b. HI variables