Investigating Spatial Clustering of Chronic Diseases at Governorate Level in Iraq-2007

Faisal G. Khamis, Muna F. Hanoon, and Saad G. Yaseen
AL-Zaytoonah University of Jordan / Faculty of Economics and Administrative Sciences, Jordan
faisal_alshamari@yahoo.com

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Abstract:
Although many studies examined the existence of spatial pattern of chronic diseases (CDs) problem in many developed and some developing countries, in improving health status and reducing inequalities between areas of such country, there is still much work to be done. Some of these studies were found spatial pattern for CDs using different statistical techniques and geographical mapping. Question is raised whether the spatial pattern of CDs rate is existed in Iraq?
The objective is to investigate the spatial structure of CDs rate across governorates, showing visual picture for health status, and to provide implications for policy makers.
Both descriptive and inference analysis were done. Study design was a cross-sectional census data for 18 governorates conducted in 2007. Mapping was used as a first step to conduct visual inspection for CDs using quartiles. Two statistics of spatial autocorrelation, based on sharing boundary neighbours, known as global Moran's I and local Moran's I_i, were carried out for examining global clustering and local clusters respectively.
Global Moran statistic $I = .06$ wasn't found significant with $z = .91$, $p = .365$ and permutation $p = .175$. Three local Moran statistics ($I_1 = 1.40,\ I_5 = .71,$ and $I_7 = .38$) were found significant with p -values (.019, .020, and .058) respectively.
In conclusion, high inequality in CDs was concentrated in eastern-northern and western-southern governorates based on visual inspection of mapping. Global clustering was not found in CDs but local clusters were found. Out of 18, three governorates were found as local clusters in CDs. Further research is needed to understand mechanisms underlying the influence of neighbourhood context.

Keywords: spatial autocorrelation, chronic diseases, mapping, global and local Moran statistics, governorates of Iraq.

1- Introduction:
Areas in close proximity with similar values produce a spatial pattern indicative of positive spatial autocorrelation. Identifying groups of areas in close proximity to one another with high and low values is often of particular interest, suggesting a cluster of elevated risk with perhaps a common source. Many diseases are spatially constrained. Disease clustering is an important issue within public health. Prior researches have produced an incomplete and often counterintuitive picture. A framework has been developed to better understand how CDs is spatially clustered across governorates of Iraq.
Many studies in several countries were shown the prevalence of CDs is very high and there is variation among studies. For example, in U.S. Wilper et al. (2008) reported that 31.3% of uninsured and 43.5% of insured had at least one of the six chronic illnesses. Furthermore, nearly 1 in 5 non-elderly adults 17.5% had a history of at least 2 chronic conditions, whereas 6.0% had 3 or more. In Southeast Michigan, Jamil et al. (2009) reported that prevalence of having any CD was 44% and the prevalence for Chaldeans was 32%, for Arabs 44%, and for Whites and Blacks 50% for each group. In Vietnam, Minh et al. (2008) reported that 39% of the respondents had at least one of the studied CDs. A Swedish study by Guez et al. (2002) reported prevalence 43%. It was reported from health survey in England (2008) that the prevalence of CDs was 6.5% in men and 4.0% in women. Of 402 Tunisians diagnosed with leukemia, 85.6% and 14.4% had chronic leukemia (Haouas & Haouas, 2011). In Sulaimani governorate, Iraq, Al-Windi (2011) stated that more than halve population reported having CD. He found the prevalence of CD higher among females 59.4% as compared to 49.4% in males based on his questionnaire data conducted during May, 2006. Hystad and Carpiano (2012) concluded that community-belonging was strongly related to health-behaviour change in Canada and may be an important component of population health prevention strategies.
In their study in Tilwana village and city of elmenofia Governorate, Egypt, Ali et al. (2010) concluded that pediatric asthma is considered the most common chronic pediatric chest problem, which has its impact on a child's quality of life. The study conducted in U.S. by Liese et al. (2012) suggested that neighbourhood characteristics related to greater affluence, occupation, and education are associated with higher type 1 diabetes risk based on multivariate generalized linear mixed models. Magalhães et al. (2011) estimated geographical risk profile of anemia accounting for malnutrition, malaria, and helminthic infections in Burkina Faso, Ghana, and Mali in 2003-2006. They found malnutrition and parasites make to anemia.

Herschel (2010) stated a general definition for Business Intelligence (BI): "BI is the application of data, technology, and analytics to gain insight and knowledge that enable decisions about people, processes and services that yield positive economics outcomes. BI is most frequently discussed relative to software application, data management activities, data warehousing, and decision support. All of these are done in this research. Data and analytics are together the foundations of BI. BI itself is referenced as a "system", an "environment", a "solution", and an offering. It is also described as a combination of "statistical and data-mining capabilities". Therefore, what have done and what are found in this research are considered as BI and as rich knowledge for policy makers regarding the problem of spatial clustering in CDs.

What is the difference between BI and analytics? BI is stated to be more about a source of data. Analytics are something used to analyze data in context of a specific issue, such as using SPLUS software in doing the analysis in this research. Analytics in this research are seen as a part of BI, but the term analytics becomes a way to distinguish various BI applications such as operations analytics, finance analytics, IT analytics, …, etc. So, BI involves a process of gathering, problem solving, reasoning, and learning to enable the successful functioning of the business system through effective decision making. Briefly, BI is a superset of tools and analytics, where it is a goal, not the means.

To understand the linkage between socioeconomic health indicators, investigation should focus on features of areas rather than on compositional characteristics of residents of the area, which cannot fully describe the social environment in which people live (Macintyre, Maciver & Sooman, 1993). In recent years, a growing interest has been seen in examining the existence of spatial autocorrelation in CD. However, governorates are tightly linked by migration, commuting, and inter-governorate trade. These types of spatial interaction are exposed to frictional effects of distance, possibly causing the spatial dependence of governorate conditions. So, the aim of the research is to study spatial autocorrelation and geographical mapping regarding CDs.

Spatial autocorrelation is the term used for the interdependence of lattice data over space. However, it was argued that lattice data are spatially correlated, where exploratory spatial data analysis (ESDA) was used. The ESDA quantifies the spatial pattern in order to increase the analyst's knowledge of the spatial system. As well as 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 statistical tables. It reveals high risk communities or problem areas (Lawson & Williams, 2001). Findings are expected to enhance health status monitoring and policing interventions across governorates in Iraq.

Reducing inequality in CDs overall is not a primary objective but emergent prosperity. The importance of this research objective emanates the hypothesis stated that CDs can reduce people opportunities in keeping their job or/and getting a high salary job. Also, to authors' knowledge no studies used spatial analysis techniques and geographical mapping in studying inequality in CDs 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). Often, this question is related to the need for public health authorities to monitor unusual aggregations of diseases in localized areas within their area of authority. These concerns may be routine in that there may be a need to provide surveillance of particular diseases and to be aware of any atypical geographical distributions. Therefore, the usefulness of the paper is to suggest where to intervene geographically. The main purpose of this study is to measure spatial clustering in CDs in Iraq, with a special emphasis on geographic distribution. In light of these: (1) the existence of spatial global clustering, and local clusters for CDs were investigated, and (2) mapping was displayed for CDs and its local Moran's I_i values. The study design is a cross-sectional analysis in a census survey conducted in Iraq in 2007.

The paper is structured as follows: Section one reviews the literature relating to CDs prevalence and disparity in several countries. Materials and methods including data and analysis are presented in second Section. Third section shows the results with several details. Discussion is explained in fourth Section. Final section is closed with several conclusions.

2- Materials and methods:

2.1- Data

Data were collected from the tabulation report of Iraq household socio-economic survey conducted in 2007. For each of (N=18) governorates, transformed CDs data were applied. CDs includes diabetes, high blood pressure, chronic inflammation, cancer, psychiatric, nervous and sensory, cardiac, respiratory, digestive, kidney disease, anemia, and other. With respect to sex, CDs for males 11.5% was slightly lower than CDs for females 14.6%. However, these percentages vary geographically. In Kurdistan region, Baghdad, and other governorates were 19.5%, 14.9%, and 10.9%.

2.2- Analysis

Data analysis involved five steps. In step 1, CDs variable was tested for normal distribution. It wasn't found to follow normal distribution. Therefore, CDs was 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 the values of skewness and kurtosis much reduced. In step 2, visual inspection based on quantified gradients for CDs was conducted using quartiles. Step 3 included the calculation of global Moran's I -statistic for CDs to detect global clustering and the significance of I -statistic using permutation test was examined. Step 4 involved the calculation of local Moran's I_i for ith governorate and it's p -value using Monte Carlo simulation to detect local clusters. In step 5, visual inspection for local Moran values was inspected based on choropleth mapping.

Maps showing diseases can help elucidate the cause of disease and may be used to generate hypotheses of disease causation. CD variable was categorized by four intervals. These intervals were used for all maps using darker shade of gray to indicate increasing value. 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 shares 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 structure of Iraq's governorates is explained in Figure 1, where identification numbers (ID) of neighbours for each governorate are shown.

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

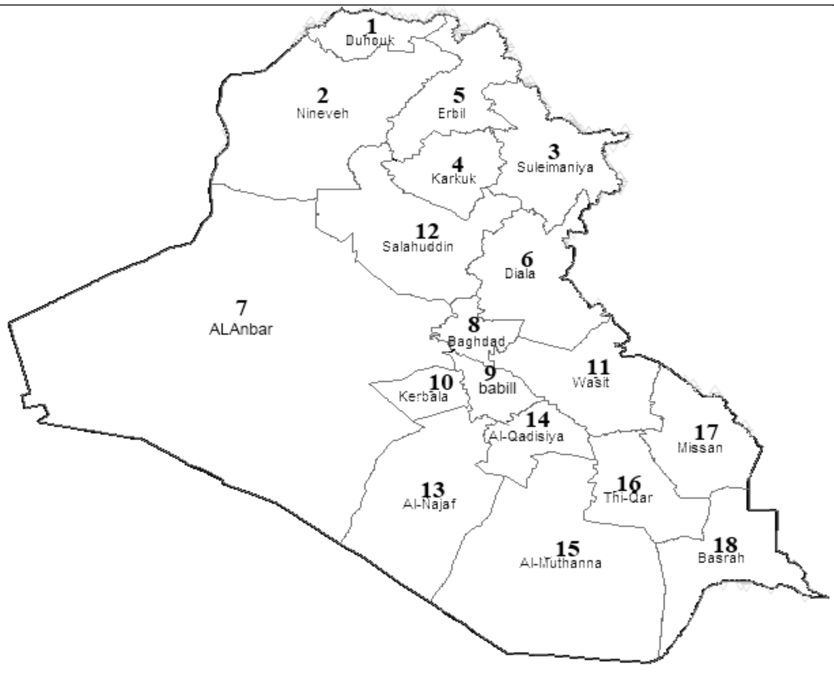

Figure 1: Study area shows all governorates with their ID and the neighbours of each governorate

To construct a choropleth map, data for enumeration governorates are typically grouped into classes and a gray tone was assigned to each class. Although maps allow visual assessment for spatial pattern, they have two important limitations: their interpretation varies from person to person, and 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 of spatial pattern, which can be accomplished using spatial autocorrelation.

2.2.1. Identification of global clustering:

The goal of a global index of spatial autocorrelation is to summarize the degree to which similar observations tend to occur near to each other in geographic space. In this exploratory spatial analysis, spatial autocorrelation using standard normal deviate (z-statistic) of Moran's I under normal assumption was tested. Moran's *I* coefficient is used to measure the strength of spatial autocorrelation in regional data. 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):

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

Where, $N = 18$ is the number of governorates, $w_{ij} = 1$ is a weight denoting the strength of the connection between two governorates i and j, otherwise, $w_{ij} = zero$, and x_i and x_j represents CDs in ith and jth 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 CDs similar to their neighbouring governorates. A significant negative value indicates negative spatial autocorrelation, showing the governorates having a high/low level of CDs unlike 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):

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

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 CDs 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.

The analysis suggests an evidence of clustering if the result of global test is found significant; though it doesn't identify the locations of any particular clusters. Besides clustering that represents global characteristic of CDs, 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 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. However, Moran's I_i for ith governorate may be defined by Waller and Gotway as:

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

Where, analogous to global Moran's I, x_i and x_j represents CDs in ith and jth governorate respectively, N_i = number of neighbours for ith governorate, and S is the standard deviation. It is noteworthy to mention that the number of neighbours for ith governorate were taken into account by the amount: $\left(w_{ij} \Big/ \sum_{j=1}^{N_i} w_{ij} \right)$, where w_{ij} was measured in the same manner as in Moran's I statistic. Local Moran statistic was used to test the null hypothesis of *no clusters*.

The most basic definition of cluster is any area within the study region of significant elevated risk. Cluster could be due to either aggregation of high values, aggregation of low values, or aggregation of moderate values. Thereby, high values of I_i suggesting a cluster of similar (but not necessarily large) values across several governorates, and low value of I_i suggesting 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 governorate has high/low value surrounded by governorate has high/low value. A negative local Moran value indicates local instability, such as governorate has low value surrounded by governorate has high value or vice versa. However, 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. In statistical analysis, all programs were performed using SPLUS8 Software.

3- **Results:**

Descriptive statistics were calculated for transformed CDs. The mean and standard deviation were found 12.72 and 4.08 respectively. Skewness and kurtosis were found .00 and -.10 respectively. The five-number summary of CDs data set consisted of minimum, maximum and quartiles written in increasing order: Min=4.64, Q_1=9.83, Q_2=12.72, Q_3=15.62 and Max=20.81. From the five-number summary, the variations of the four quarters were found 5.19, 2.89, 2.90 and 5.19 respectively, where the 1^{st}. and 4^{th}. quarters have the greatest variation of all.
Figures 2a and b show visual insight for CDs and its local Moran values respectively. Darkest shade corresponds to the highest quartile. These maps display geographical inequalities across governorates of Iraq. Based on visual inspection taken from Figure 2a, an overall worsening pattern (higher scores) was found in eastern-northern and western-southern parts. The same was approximately found regarding visual inspection taken from Figure 2b for local Moran values of CDs that worsening pattern was found in eastern-northern and western parts.
Suggestion of spatial clustering for CDs that follows a visual inspection of mapping was not confirmed by global Moran's I of .06 with an associated z -statistic of .91 and $p = .365$. Although global clustering was not confirmed, permutation test was done. Permutation $p = .175$ wasn't found significant. Thus, the null hypothesis of no spatial autocorrelation wasn't rejected accordingly. But, three significant local clusters (hot spots) were found. These clusters: 1, 5, and 7 are located, as shown in Figure 2b, in northern and western parts. Table 1 shows local Moran values of CDs variable and their p -values.

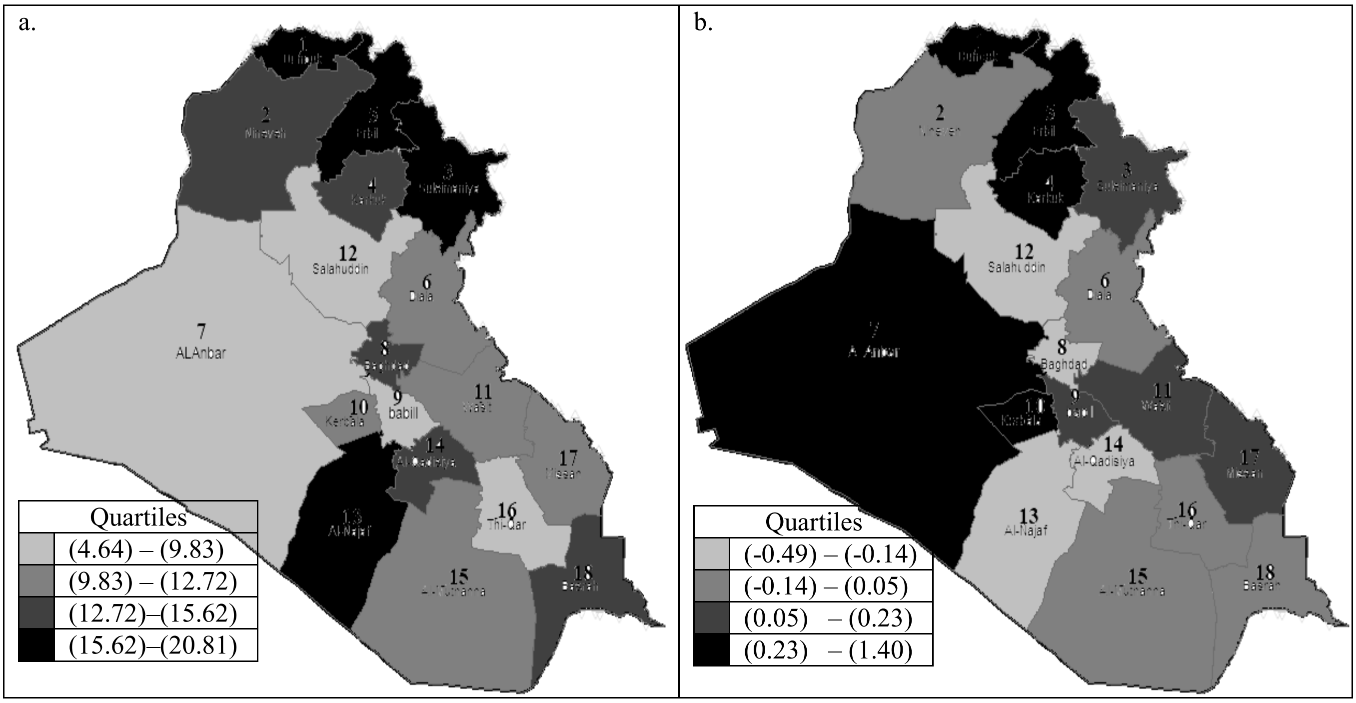

Figure 2: Choropleth maps show visual insight for: a. CDs variable and b. its local Moran values

Table 1: Shows transformed CDs variable, its local Moran's I_i values, and their corresponding p-values (significant values are written in boldface at .10 level).

ID	Transformed CDs	I_i	p
1	18.29	1.40	**.019**
2	13.00	.01	.442
3	17.08	.20	.189
4	14.15	.23	.204
5	20.81	.71	**.020**
6	10.68	-.02	.507
7	4.64	.38	**.058**
8	14.76	-.47	.900
9	9.26	.14	.186
10	10.02	.25	.157
11	11.30	.10	.226
12	8.36	-.23	.809
13	16.18	-.49	.905
14	15.43	-.24	.786
15	12.44	-.01	.472
16	7.15	-.07	.606
17	11.88	.10	.300
18	13.57	-.11	.645

Simulated data are useful for validating the results of spatial analysis. 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 CD. 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. While research results were specific to these data, the case study helps to identify general concepts for future studies.

4- Discussion:

The above framework has 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. This study adds to the global body of knowledge on the utilization of spatial analysis to strengthen the research–policy interface in developing countries such as Iraq. Although, this work was conducted as part of a wider study, its immediate implications are more for policy makers and practitioners than for researchers. Spatial patterns had shown concentration of highly CDs in old governorates such as Duhouk, Erbil, and Alanbar. The contribution to literature on CDs was shown by explaining where these patterns were located in Iraq. Findings of this study suggest that tackling CDs is a high priority. It should foster efforts to ensure that CDs prevention strategies include urban poor governorates.

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 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.

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 a 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 (HI). Generally, low income leads to several CDs. Iraq before, in, and after 2007 faced specific challenges with regard to jobs in its state-owned enterprises. With over 500 000 workers on the payroll, state-owned enterprises are a major source of employment. Analysis of other episodes of conflict in Iraq indicated 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. Most researchers recommend designing global development strategies that focus on job creation and income generation, and incorporate elements of basic social protection and social dialogue at the global and local levels as an attempt to reduce inequalities in CDs.

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 observed values are spatially clustered, the samples are not independent. Increasing in CDs level in governorate i generates increasing in CDs level in governorate j. This mechanism of transmission leads to spatial autocorrelation in CDs.

Anselin (1995) stated that indication of local patterns of spatial association may be in line with a global indication, although this is not necessarily be the case. It is quite possible that local pattern is an aberration that global indicator would not pick up, or it may be that a few local patterns run in the opposite direction of global spatial trend. 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. However, this is found in this research. Although global Moran statistic was not found significant, three local Moran values were found significant. Limitation of this study was that causal relationship can't be drawn due to this can only be done in prospective studies.

The obvious question after finding significant clusters in CDs 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 CDs and other socioeconomic indicators. The lack of adequate health care, health care system and adequate management could also belong to the reasons for poor health. This research will be our interest in Iraq and other developing countries in the near future. As stated by Barkera (2012), prevention of chronic disease and an increase in healthy aging require improvement in the nutrition of girls and young women. Many babies in the womb in the Western world today are receiving unbalanced and inadequate diets. Many babies in the developing world are malnourished because their mothers are chronically malnourished.

In essence, it should be emphasized that CDs problem cannot overcome in the short-run; but long-term efforts are needed to tackle inequalities across governorates. In turn, enabling the economy to create more job opportunities and establish new projects, especially in governorates that are found as hot spots. It means that the place of the problem is now clearly shown. Health inequalities are ubiquitous around the world. Thus, fresh perspectives to tackle inequalities are always welcomed by the research community invested in reducing and eventually eliminating these inequalities. 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 four aspects. First, visual inspection shows that high level in CDs was concentrated in eastern-northern and western-southern governorates. While low level in CDs was concentrated in middle and some northern and southern governorates. Second, several governorates such as Alanbar, Kerbela, and Babil are not observed visually as hot spots. But, after considering the information of their neighbours, i.e. calculating their local Moran's I_i values, the pattern of their hot spots can be obviously seen. Third, global clustering in CDs was not found significant. However, three governorates: Duhouk, Erbil, and Alanbar were found significant local clusters. Forth, from negative local Moran values, looking at the local variation, some governorates were seen as areas of dissimilarity, such as Baghdad and Alnajaf. i.e., these governorates having low CDs were surrounded by governorates having high CDs or vice versa. These conclusions are useful for organization and follow-up of medical care. By providing the necessary knowledge, patients and family are encouraged to effectively manage the disease process and improve their quality of life.

Maps were displayed geographical inequalities in CDs across governorates of Iraq. The analytical approach used here delineates governorates of relatively high CDs. This permits policy makers to develop strategies that minimize this inequality. Policy which pays attention to area characteristics will probably reduce CDs inequality. Consequently, this will generally improve population health in affected governorates. In summary, this study supports the hypothesis of spatial clustering in CDs at governorate level that probably reflects inequality distribution in several socioeconomic indicators. However, direct investments in appropriate health interventions could be necessary to reduce CDs inequality. Further research is required to investigate spatial clustering in several socioeconomic indicators attempting to explain hot spots in CDs.

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