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Statistical map analysis of the mean and the gini coefficient of healthcare expenses in Iran

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Abstract

In many modern societies, the concepts of equity and equality are the most important notions for statesmen and people. Due to the rapid increase of expenses in the healthcare sector, more emphasis should be placed on measuring and monitoring inequalities across the country. This study aimed to evaluate inequalities in healthcare expenses, predict these expenses in Iran's cities and prepare and interpret a statistical map. The data related to household' healthcare expenses for 335 cities have been received from the Statistical Center of Iran. Data preparation, estimation and calculation of indicators have been carried out by programming in S-PLUS software. Spatial analysis and predictions were performed by geoR software and plotting statistical maps were carried out by Arcgis 9.2 software.
According to the results, the mean and the Gini coefficient for cities are increasing from the East to the West of Iran on average. The Gini coefficient of expenses in all cities is high and especially inequality is higher in cities located in deserts and deprived areas than in other parts and the greatest inequalities are obtained for the cities in Provinces of Sistan-Baluchestan and some parts of Hormozgan province. To reduce inequalities and realize equity in healthcare, the government should try to allocate a special budget for decreasing the healthcare and medical expenses.

Keywords: Geographic mapping, Health expenses, Inequality, Spatial Analysis

Introduction

Today, concepts such as social welfare and equity in different areas such as social, economic, cultural and health are among the most important concepts for statesmen and people in many countries. One of the tools for sustainable development is to make social equity in all areas including the healthcare sector. A concept of equity in financial contribution is that households are protected against catastrophic medical expenses. Government can improve this equity with proportional distribution of healthcare facilities, subsidizing indirectly and the development of insurance services. Clearly, increasing indirect government supports decrease the mean of healthcare expenses. Since 1900, measuring inequality of income and wealth distribution has been attended by defining the inequality measurement indicators such as the Gini coefficient. Unorganized markets, unequal distribution of income and wealth are more

beneficial to investors and employers, will lead to inequalities in society so that a major part of the income and wealth belongs to a small minority of people and a small portion of it is distributed among the majority of them.

The unfair distribution of income and wealth, unorganized markets, different levels in communities, and as a result the different needs are effective on inequality in expenses and other aspects of people's lives, causing many problems for people and statesmen, particularly in the context of planning and implementation economic plans [1].

Using economic tools and concepts in problems related to health and healthcare are among important topics in health economics. Economists pay attention to the healthcare for different reasons. First, resources for healthcare are limited, as in other cases, the demand for health services is greater than the supply. In addition, limitation and scarcity cannot be alleviated easily by increasing healthcare expenses because the importance of opportunity expenses is ignored. The concept of equity in household financial participation in the healthcare system was defined as "equal expense share" by the World Health Organization's World Health Report 2000, i.e. households will pay out a share alike according to their ability to pay for the healthcare system. This means that households with higher incomes will participate more than households whose income is less, so that health expenses share of both groups is the same according to their total income. A notion of equity in financial contribution is that households are protected against catastrophic medical expenses [2].

Health expenses in low-income countries are still directly provided through OOP payments and pre-payment mechanisms such as taxes and health insurance. Rapid increase in healthcare expenses, particularly the expenses of diagnosis and treatment over the world, has made experts including economists, managers and even physicians and nurses and health professionals in many countries find new ways to limit these expenses [3].

In Iran, like other countries, households' healthcare expenses (including expenses of medical goods and supplies, medical outpatient services, hospital services, addiction withdrawal expenses, etc.) will form a part of the total expense of households and certainly has lrlationship to households' income. Clearly, the amount of expenses varies from one household to another, so interesting statistical surveys can be conducted on their distribution across the country. For example, inequality indicators such as the Gini coefficient and statistical indicators such as the mean can be calculated for them. Differences in the distribution of expenses are due to the differences in available facilities, standard of living, health level, household's conditions and culture, geographical conditions and even households' income.

Every person or household spend a portion of his expenses on healthcare affairs. Aging of some household members, persistent or incurable diseases and accidents will increase the expenses and therefore increases the households' total expenses. The mean of households' healthcare expenses can represent public health level to some extent because any increase in the expenses shows a problem in a part of the community. Studying and comparison of the mean expense in different cities and provinces can clarify some information hidden in data and highlight troubled cities, which is one of the purposes of this paper. On the other hand, calculation and comparison of the Gini coefficient of expenses (for all cities or provinces) can indicate the inequality of healthcare facilities for the residents of different cities, as a big Gini coefficient in a city shows that there is a large inequality between different individuals' share of expenses. However, these indicators alone are not indicative strength and weakness of the performance for the healthcare sector, because they are dependent on other indicators such as individuals' mean income, the level of social welfare and the population rate of aging.

In this paper, the mean and the Gini coefficient of households' healthcare expenses in

different cities are considered as two spatial data set. Data obtained from different locations or various geographical places (for example, different parts of a town or city) being called spatial data. These type of data have a spatial dependence which usually decreases by increasing the data distances. For this reason, the Kriging method (an advanced statistical technique for spatial prediction and preparing a statistical map) is used to predict the mean and the Gini coefficient of households' healthcare expenses in different cities and then geographic distribution map of these two indicators is plotted and their trend will be examined.

Method

The data used were provided by the Statistical Center of Iran(SCI) through the plan of "Survey of Household Income and Expenses, 2008". The plan's questionnaire included hundreds of questions in areas such as socio-economic characteristics of household members, living place information, life facilities, food expenses, clothing expenses, housing expenses, households' healthcare expenses in the past month and so many other cases. The surveyed population included all typical households living in urban and rural areas of Iran in 2008. The participant size of the project, was obtained based on plan's goals using statistical formulas across the country, which includes 39,305 households containing 19,835 rural households and 19,470 urban households. The participant size varies in different provinces, so that it ranges from 995 households (Semnan province) to 2,275 households (in Tehran). Healthcare expenses include cases such as medical products and devices, medical outpatient services, hospital services, and addiction withdrawal expenses [4]. After data filtering and its preparation, statistical and economic indicators were calculated via programming in S-PLUS software To evaluate inequality in expenses. The first indicator is the mean of households' monthly healthcare expenses in different cities (in Rial). The indicator across the cities in the country ranges from about 9000 Rials in the city of Jask (located in Hormozgan Province) to 4400000 Rials in the city of Sardasht (located in West Azarbaijan).

The next indicator is the Gini coefficient of this expense. The Gini coefficient is measurement indicator of inequality that was introduced by Corrado Gini in 1912 for the first time, which was based on Lorenz curve. The Lorenz curve is the most important graphical tool for introducing economic inequalities. To draw the Lorenz curve, cumulative relative incomes of people surveyed are represented on the vertical axis and cumulative relative frequency of the corresponding population is represented on the horizontal axis [5]. The Gini coefficient according to definition is twice of the area between the Lorenz curve and the bisector line. The Gini coefficient is a non-negative indicator whose value is always between zero and one, its minimum value is zero representing a perfect equality and its maximum value is one indicating a perfect inequality in the distribution of the interested variable [6]. The Gini coefficient can be estimated for each data set by statistical software, especially a program called ineq written in R software [7]. The Gini coefficient has been mainly used to measure income distribution inequality and economic indicators. In this paper, for the first time the Gini coefficient and some common statistical indicators are used for measuring inequality and comparing the distribution of households' healthcare expenses in different cities.

The Gini coefficient value of households' healthcare expenses in different cities of Iran ranges from 0.4 in the city of Kalat (located in Razavi Khorasan Province) to 0.97 in the city of Iranshahr (located in Sistan-Baluchestan Province). The value of this indicator is almost medium to high in different cities and this means that inequality in households' monthly healthcare expenses is nearly high in most cities of Iran.

As we metioned before the mean and the Gini coefficient of households' monthly healthcare expenses in different cities of Iran with latitude and longitude of the intended city center are considered as two spatial data

sets. Since these data have a special type of dependence (because of proximity effects,) their dependence structure is estimated by an indicator called variogram as variance of the difference between observations at two locations and then one or more variogram models are fitted to it, and the appropriate model is selected [8,9]. To detect the better model, weighted sum of squared residuals of the model is used and a model with the least sum of weighted squares would be the more appropriate model [10]. Figures 1 and 2 indicate the plot of data's variogram and the best fitted model. Spatial prediction is usually done for the points (or locations) from which no data is available, for example, for a town or city that is not in participantd or is developed later due to changes in administrative divisions. In this paper, before preparing expenses map, the indicator is predicted for each city to eliminate the random variation in indicators' changes (or, its smoothing). The Kriging method is one of the common methods for spatial prediction in a new location with the coordinates based on spatial data . For making predictions in this method, a linear combination of data is used as . Using advanced statistical and mathematical methods, the coefficients of this linear combination are determined such that this predictor be unbiased with minimum-variance. The Kriging method give more weight on near observations and less weight on far observations which is done by following the nature of spatial data correlation which,usually, reduced with increasing of data distances. The Kriging formulas are not mentioned because of their complexity; the reader can observe them in various references [8]. People who are familiar with programming in R software can perform statistical calculations of variogram modeling and Kriging prediction by geoR software [11]. Before spatial prediction, at first the stationary and isotropy of the mean and the Gini coefficient of households' healthcare expenses in cities were examined by plots and fitting the regression models and it was observed that these two data sets have no trend and almost stationary, and in addition are isotropic (i.e. data have initial conditions for the application of Kriging method).

Results

As mentioned in the previous section, "variogram" is used to measure and model the spatial data dependence form. After calculating the variogram of data, various models are fitted and the most suitable model is chosen. Figures 1 and 2 show the variogram of the mean and the Gini coefficient of healthcare expenses and two fitted model. In these plots, the horizontal axis shows distances between cities and the vertical axis shows the corresponding variogram of distances. Increased value of the variogram shows that by increasing the distance between cities the dependence of the mean health expenses and the Gini coefficient of expenses is reduced [12,13].

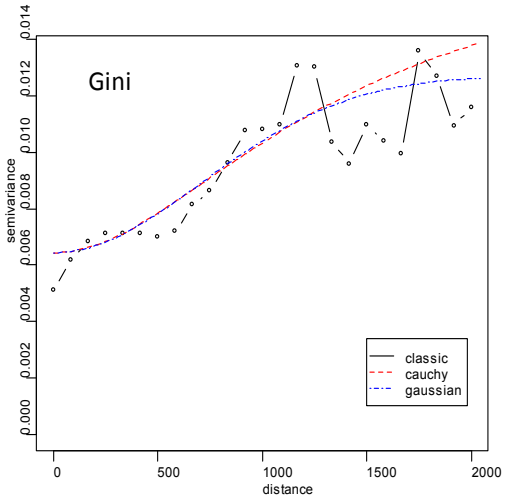

Figure 1 *Plot of estimation and fitted Models for the mean of expenses*

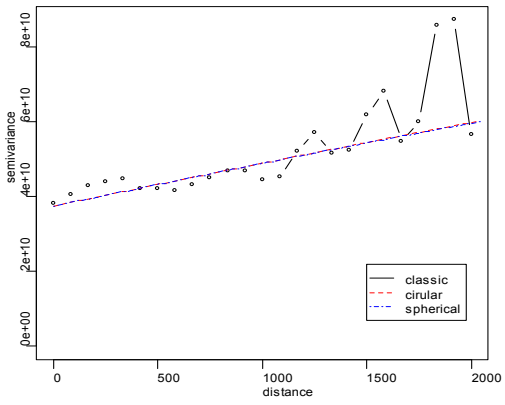

Figure 2 *Plot of variogram and fitted Models for the the Gini Coefficient of expenses*

To increase the accuracy of spatial predictions after fitting different models, circular model was selected for mean data sets and the Gaussian model was chosen for the Gini coefficient data sets (due to lower error) as more suitable models [12]. Circular model parameters estimation is (4630.03, 4.2×1010, 3.75× 1010) and the Gaussian model parameters estimation is (1000, 0.0063, 0.0064). These parameters from right to left show the range, sill and nugget effect of the model. Using the above models and the Kriging method the mean and the Gini coefficient of households' healthcare expenses in different cities of Iran were predicted, via geoR Software. Figure 3 shows prediction map of the mean of healthcare expenses in cities. In this figure, cities are marked with a range of 7 colors and increased darkness of the color indicates an increase in the mean expense of residents in cities.

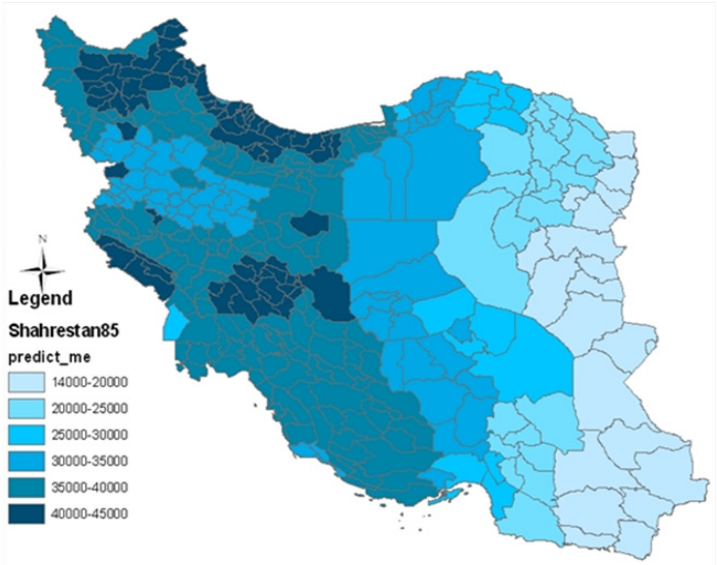

Figure 3 *The map of mean of households' monthly healthcare expenses according to different cities*

According to Figure 3, an interesting trend is observed in the mean healthcare expenses because the mean of households' monthly expenses is increasing from the East to the West of Iran and the lowest expense is obtained for cities located in the Eastern part and the highest expense for the Northern and Northwestern cities. According to the map, cities located in the Eastern border of Iran (in three provinces of Sistan-Baluchestan, Southern Khorasan and Khorasan_e razavi) on average have lower mean of healthcare expenses than other cities. Similarly, the Gini coefficient of healthcare expenses in each city is predicted by the Kriging method and the map is prepared by

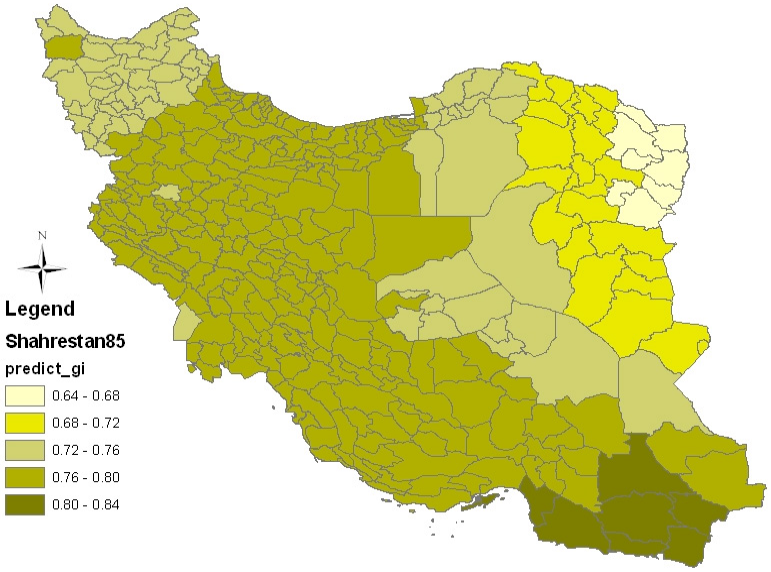

Figure 4 *The Gini coefficient map of households' monthly healthcare expenses according to different cities*

ArcGIS software, as can be seen in Figure 4. According to Figure 4, the Gini coefficient of households' monthly healthcare expenses in cities varies between 0.64 and 0.84. According to the map one can observe that inequality in the distribution of healthcare expenses is rising almost from the East to the West of Iran country. The lowest Gini coefficient is predicted for East and Northwestern provinces. According to Figure 4, it can be also seen that some parts of southern of Sistan-Baluchestan Province have the highest inequality in the distribution of healthcare expenses and some parts of the Northeastern of Khorasan_e Razavi Province have the lowest inequality in the distribution of healthcare expenses.

Discussion

Every person has the right to benefit from healthcare facilities to achieve the lifetime maximum health. Furthermore, maintaining family members' health is one of the most important functions of families, hence, a part of family's income should be allocated to healthcare. Expenses of healthcare are increasing day by day. Households without complete health insurance coverage are exposed to the risk of extensive medical expenses. This risk will reduce welfare. If incurred medical expenses are greater than household's income, the severe decline in living standards may be catastrophic. The investigations of this study show that the mean of households' monthly healthcare expenses varies from about 9000 to 4400000 Rials in different cities that exhibits a severe dispersion. It can be stated that the mean related to cities located in the western side and central part is higher than other cities. In Figure 3, it is observed that the mean of healthcare expenses of cities rise from the East to the West of the country. Reduced healthcare expenses like a two-sided coin have two different interpretations. This reduction can indicate a high health level of the whole community or can be due to poverty (reduction of income resulting in decreased purchasing power). As a result, the trend of changes need further investigation in order to find the cause to determine whether people in the Eastern provinces have really fewer healthcare problems, are more satisfied or spend lower expenses for their healthcare because of lack of income. Predicted values of the Gini coefficient of households' monthly healthcare expenses of cities vary between 0.64 and 0.84. According to the color spectrum in Figure 4, it is easily observed that inequality in the Gini coefficient of expenses increases from the East to the West of the country. Also, according to Figure 4, it can be seen that southeast of the country, especially the southern parts of Sistan-Baluchestan Province have the highest inequality in the distribution of healthcare expenses and this inequality should develop concern for health policymakers, especially in the borders provinces.

Conclusion

This study shows that the Gini coefficient is high in all cities; especially inequality of the expenses in cities located in desert and deprived areas is higher than other parts of the country. On the other hand, the maps show that this inequality rises from the East to the West. The greatest inequality has been predicted for cities in Sistan-Baluchestan Province and a part of Hormozgan Province. The government should try to reduce inequality with the allocation of special budget to these parts, especially in disadvantaged cities and realize healthcare equity in addition to discovering the main reasons for this. One of the reasons for high Gini coefficient is large dispersion or fluctuations in expenses of different households that this is due to the difference between people in terms of health and diseases. According to some studies, the Gini coefficient of income in urban areas of the country (in 2008) was 0.37 and in rural areas was 0.40 [14]. Therefore, the inequality in healthcare expenses is much greater than income inequality. In a study conducted by the Applied Research Secretariat, Ministry of Health and Medical Education, the Gini coefficient of healthcare expenses was reported about 0.78 for the whole country

in 2003 [15], while according to the current study, it was 0.82 in 2008 for the whole country and varied from 0.71 (Khorasan_e Razavi) to 0.92 (Hormozgan) for different provinces [12]. So, it is found that inequality in expenses has increased in the past years. This inequality is intensified because of elderly people and patients who are treated consistently, or need costly treatments. These people increase the mean of expenses as well as inequality.

To reduce inequality, prodigal households' expenses should be reduced and thrifty households' expenses should be increased. Preventing costly surgeries or using less expensive treatment methods instead of expensive therapies in addition to reducing households' expenses burden and improving people's economic situation, will reduce the mean and the Gini coefficient of expenses as well. It seems that there are statistical relationships between healthcare expenses and the percentage of the elderly that this requires another study.

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Contributions

Study design: YW, GRMB
Data collection and analysis: SNT
Manuscript preparation: YW, SNT

Conflict of interest

"The authors declare that they have no competing interests."

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