The use of the spatial trend surface model to predict the distribution of health cadres from pharmacists in Wasit Governorate

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Abstract. Wasit governorate suffers from a poor distribution of health personnel from pharmacists, their concentration in some aspects, and their lack of others. In order to determine the pattern and distribution of the cadres of pharmacists, some of the spatial inference models were used in the prediction process to reach a fair distribution for pharmacists in the governorate, which is the trend surface model of the first, second and third degrees, reviewing the results using the Geo Data program. We estimated the trend surface model after assuming a certain spatial covariance function. In terms of parameters called covariance components, the components were estimated using the MLE method that adopted the Newton-Raphson iterative algorithm Then we compared these models to determine the best model that represents these data, using the criteria (AIC, BIC R2) and we concluded that the best model is the first-order trend surface model. To find out whether there is fairness in the distribution of pharmacists in the governorate the two statistical indicators were calculated the Lorenz curve and the Gini coefficient for the original and predicted data using the i-xplore program. The Lorenz curve showed the lack of equality in the distribution of pharmacists in the governorate and this was confirmed by the Gini coefficient, either for the data predicted, the Lorenz curve showed that there is fairness in the distribution of pharmacists within the governorate, and that the Gini coefficient proved that there is no discrepancy in the distribution.

Key words. Gini index, Lorenz curve, first, second, and third order directional surface model. Spatial variance models.

1. Introduction
Spatial analysis is a scientific method that aims to study all types of resources and capabilities available in the state, city, or institution, as well as determining how to use these services to achieve goals and improve conditions, and on this basis the spatial analysis process is closely related to serious scientific studies of human resources and available services as well as knowledge The extent of its efficiency and the patterns of its distribution. And the possibility of using these services, on the basis of which the goals
sought by society can be achieved. Health services are the main pillar on which people depend in their development and progress, and in solving many of the problems that society suffers from. Therefore, studies must be conducted that show how spatial planning for the distribution of health services, which is one of the most important services that societies seek to provide everywhere in the world. To study this, we used a model of spatial inference models, which is the trend surface model of the first, second and third order to predict and reach a fair distribution of health cadres from pharmacists in the governorate using the Geo Data program, and then we compared these models to determine the best model that represents these data the best representation using MSE standard, Akaike criterion (AIC), Schwartz standard (BIC), and coefficient of determination standard ($R^2$). Likewise, the (I-xplore) program was used to compare between the original and predicted data to measure the degree of difference or disparity and to know whether there is fairness in the distribution of health cadres from pharmacists in the governorate or not by using the two statistical indicators (Lorenz curve index and Gini coefficient index. The researchers used Muhammad Nazir. Ismail and Dina Adoni Odisho [16] “In (2007) the trend surface model in the analysis of real spatial data, which represents the rise in groundwater levels in the Al-Qaim region, western Iraq, and the results of the estimation and prediction were encouraging and good. In (2015) the researcher, Albiyati presented, Jaafar Musa Muhammed [2]. Spatial estimation models of the pure pattern represented by the inverse distance weighted model, the directional surface analysis of the first order and your normal corner with the MAE and RMSE calculation for these three methods as criteria to determine the best method to be adopted in the prediction process

2. Objective of the research.
Determining the pattern of distribution of services in the health sector, measuring the disparity in it, and determining the effect of this distribution on the individual in that region, using statistical indicators in order to arrive at the best method representing the symmetrical distribution of these services after studying the reasons for this distribution and how to address it to reach a regular and fair distribution and then forecasting to know the effect of this Distribution and its pattern on the individual and on that region, using spatial inference models.

3. Location variable
The variables dealt with in spatial statistics differ from the usual variables, as each value of the local variable has coordinates representing that point, whether it is on the surface of the earth in the plane or in the ground or outside the earth (for example, air pollutants such as gases). The locational variable differs from the variables that are used in classical statistics, and this variable was also defined by the spatial variable by Matheron (1963) [6] who is considered one of the first pioneers in this field. That the spatial variable represents the services present in a specific site or sites in A logic, denoted by the symbol $Y(s)$, since $S \in R^r$ and $R^r$ is the Euclid space with two dimensions $r = 2$, $S = (u(s), v(s))$ or three dimensions $r = 3$, $S = (u(s), v(s), w(s))$.

The theory of spatial statistics depends on studying the differences between the spatial variables $Y(s)$ and $Y(s + h)$, since $Y(s)$ is the amount of services present at the site of $S$ and the services $Y(s + h)$ at a site far from the site $s$ with a displacement $h$ and $h$ represent the traditional distance between the two sites, it may be [16, 18, 19, 11]:

$$|h| = \sqrt{u^2(s) + v^2(s) + w^2(s)}$$

The spatial variable $Y(s)$ is a function of a random variable because we do not know with certainty about the value of this variable at the particular site until after studying the study site [19, 11].

4. Spatial inference models
It works the same as the linear regression model in predicting the values of the dependent variable, but in these models it will be on the quantitative as well as the spatial (geographical) level [2]. In these
models, we will analyze the non-spatial values of a group of locations (points). There are several methods of spatial inference or methods of estimating spatial data, including [13].

the first order trend surface model
The trend surface analysis approximates points with known values with the polynomial equation and that this estimation can then be used in estimating the values of other points. Therefore, the first order trend surface equation is in the following formula [17]:

\[ Z(x, y) = b_0 + b_1 x + b_2 y \]

Since: Z(x, y) is a coordinate function, b0: represents the height of the point from the surface, b1: represents the rate of change of the surface height in the direction of x, and b2: represents the rate of change of the surface height towards y. That the trend surface analysis includes the description of spatial data by means of a mathematical order polynomial of a certain order with two dimensions of the stochastic process \[ Y(s), s \in D \]. Suppose that a view in position i can be written as [2]:

\[ Y_i = Y(s_i) = Y(u(s_i), v(s_i)) \]

Since: Si = (u(si), v(si)) 'and that: v and u represent the cartesian coordinate system for the D area under study. And the residual component Ri, meaning that [2,17]:

\[ Y_i = T_i + R_i \]

the second order trend surface model
The mathematical formula for this model is

\[ Z(x,y)=b_0 + b_1 x + b_2 y + b_3 x^2 + b_4 y^2 + b_5 xy \]

Since: Z(x, y) is a coordinate function, b0: represents the height of the point from the surface [2], b1: represents the rate of change of the surface height towards X, b2: represents the rate of change of the surface height in the direction of y. We use the general least squares method to solve the equations b0, b1, b2 [17, 21].

\[
\begin{bmatrix}
  n b_0 + b_1 \sum x + b_2 \sum y = \sum z \\
  x b_0 + b_1 \sum x^2 + b_2 \sum xy = \sum xz \\
  y b_0 + b_1 \sum xy + b_2 \sum y^2 = \sum yz \\
\end{bmatrix}
\begin{bmatrix}
  b_0 \\
  b_1 \\
  b_2 \\
\end{bmatrix}
= \begin{bmatrix}
  \sum z \\
  \sum xy \\
  \sum yz \\
\end{bmatrix}
\]

With the possibility of finding the equations using a function of the ML.

5. Maximum Likelihood Method
Mardia and Marshall (1984) counted a method for estimating the Maximum Likelihood Method of the parameters of a spatial regression model in which the random errors are self-correlated. The self-covariance between any two observations of Y can be defined by the parameters of the Parametric model as a function of the position between these two observations, which depends on the distance between the two sites of views. And a set of unknown parameters θ. We also know that the auto covariance matrix Ω must be a positive certainty matrix. Assume that the stochastic process Y(s) is a Gaussian process and it is not assumed to be stable, that is, [1,16]:

\[ E(Y(s)) = \mu(s) = f(s) \beta \] and \[ COV (Y(s), Y(s*)) = C(h, \theta) \]

Whereas: \( \beta \) is the vector of the directional parameters of the dimensions (k \times 1) and \( \theta \) the vector of the parameters of the covariance function with dimensions (r \times 1) and f(s) is a vector known from the functions that represent the coordinates of the locations of the observations, h the conventional distance between the observation Y(s) and Y(s*). It is required to estimate the two parameters (β, θ) by the Maximum Likelihood Method and to estimate (β, θ) we take a random sample of size n from the observations from the random process, \{Y(s), S \in D \}. Where D : is the domain of the study area, that
is, the random sample of size n is represented by the observations \(Y(S_1), Y(S_2), \ldots, Y(S_n)\), and \(S_1, S_2, \ldots, S_n\) represents the locations of the observations \(S_i \in D, \forall \ i = 1, 2, \ldots, n\) and can be represented by the following linear model:

\[
Y(s) = f(s) \beta + e(s), \quad S_1, S_2, \ldots, S_n \in D
\]

Where \(e(s)\) is the random error that is distributed in the Gaussian distribution such that \(E(e(s)) = \mathcal{N}(0, \sigma(h, \theta))\) and the model can also be written to \(Y = (Y(S_1), Y(S_2), \ldots, Y(S_n))\) in matrix form as follows:

\[
Y = XB + e
\]

Where \(X\) is the information array of location coordinates. \(e\): the random error vector of dimensions \((n \times 1)\).

\(\Omega(\theta)\): the covariance matrix, which is a function of the covariance parameters \(\theta\). And that \(Y(S)\) is the Gaussian distribution \(Y \sim \mathcal{N}(XB, \Omega(\theta))\). That \(\Omega(\theta)\) is used to denote which is a function in terms of parameters \(\theta\) and \(Var(e) = Var(Y)\), the probability function can be written for the parameters \(\beta\) and \(\theta\) as follows:

\[
f(Y; \theta, \beta) = \frac{1}{\sqrt{(2\pi)^n \Omega(\theta)}} e^{-\frac{1}{2}(Y-XB)\Omega^{-1}(Y-XB)}
\]

And taking the logarithm to the Maximum Likelihood we get

\[
L = \log f(Y; \theta, \beta) = -\frac{n}{2} \log(2\pi) - \frac{1}{2} \log|\Omega| - \frac{1}{2} (Y - XB)'\Omega^{-1}(Y - XB)
\]

By differentiating \(L\) with respect to \(B\) and setting it equal to zero and assuming \(\Omega\) that is a given, we get the estimate as follows:

\[
B = (XB + e) = \Omega^{-1}(Y - XB)
\]

Where \(\Omega\) is obtained from equation (7) after estimating the covariance matrix \(\Omega\) after estimating the parameter by differentiating \(L\) with respect to \(\theta\) and that \(\theta = (\theta_1, \theta_2, \ldots, \theta_r)'\). Therefore, we will need the following equations:

\[
\frac{\partial \log|\Omega|}{\partial \theta_i} = \text{tr} \Omega^{-1} \frac{\partial \Omega}{\partial \theta_i}
\]

\[
\frac{\partial \Omega^{-1}}{\partial \theta_i} = -\theta^{-1} \frac{\partial \Omega}{\partial \theta_i} \Omega^{-1}
\]

Where \(\text{tr}\): represents the matrix effect of any \(Z\)-matrix

\[
\text{tr}Z = \sum_{i=1}^{n} Z_{ii}
\]

\[
\frac{\partial L}{\partial \theta_i} = -\frac{1}{2} \text{tr} \Omega^{-1} \Omega_i + \frac{1}{2} W' \Omega^{-1} \Omega_i \Omega^{-1} W
\]

Where \(W = Y - XB\), \(\Omega_i = \partial \Omega / \partial \theta_i\), and when finding \(\hat{B}, W = Y - XB\). Equation (10) can be written in a simpler way as follows:

\[
\frac{\partial L}{\partial \theta_i} = -\frac{1}{2} \text{tr} E \Omega_i, \ i = 1, 2 \ldots r
\]

Where \(E = \Omega^{-1} - V\)

\[
V = \Omega^{-1} W
\]

Thus, equation (11) can be solved iteratively by using Newton Raphson’s method, and to find the roots of equation (10) we need other results for the derivation

\[
\frac{\partial^2 \Omega^{-1}}{\partial \theta_i \partial \theta_j} = S_{ij} \Omega^{-1} + S_{ji} \Omega^{-1} - R_{ij}
\]

\[
R_{ij} = \Omega_{ij} \Omega^{-1}
\]

\[
S_{ij} = \Omega^{-1} \Omega_{ij} \Omega^{-1}
\]

Where \(\Omega_{ij} = \frac{\partial^2 \Omega}{\partial \theta_i \partial \theta_j}\)

From this, we find that equation (13) is obtained from the derivation of equation (9) with respect to \(\theta_j\), but when deriving equation (8) with respect to \(\theta_j\), it will be obtained

\[
\frac{\partial \log|\Omega|}{\partial \theta_i \partial \theta_j} = -\text{tr}(S_{ij} - R_{ij})
\]
Because for any array of constants $x$ we'll use the corollary $\frac{\partial}{\partial \theta_i} \text{tr} \Omega = \text{tr} \Omega_i$

By applying this result to equation (8), equation (15) is obtained. When deriving equation (10) with respect to $\theta_j$ and using equation (9), it will be obtained:

$$2 \frac{\partial^2 l}{\partial \theta_i \partial \theta_j} = -\text{tr}(R_{ij} - S_{ij}) - W'(S_{ij} + S_{ji} - R_{ij})\Omega^{-1}W$$

Since the vector $Z \sim N(0, \Sigma)$, then for any matrix $A$ we have

$$E(Z'AZ) = \text{tr}A \ E(Z'Z) = \text{tr}A \ \Sigma$$

After taking the expectation for equation (16), we get

$$E\left(-\frac{\partial^2 l}{\partial \theta_i \partial \theta_j}\right) = \frac{1}{2} \text{tr} S_{ij}$$

Since $S(ij)$ was previously defined in equation (14). Assume that

$$A = \frac{1}{2} \text{tr} S_{ij}, i, j = 1, 2, \ldots, k$$

Thus, $A$ can be substituted for the information matrix, and equations (17) and (11) can be solved iteratively, as we assume initial values for the parameter $\theta$, for example $\theta_0$, then find $\Omega_0$, then $\tilde{B}$ and then we apply the following Newton Raphson method:

$$\theta_{k+1} = \theta_k + A_k^{-1} \delta_k$$

Since $AK$ is a matrix of equation (17) computed at the parameter $\theta_k$ and $\delta_k$ is the vector of the derivatives computed at $\theta_k$ and $\tilde{B}_k$ from equation (11) i.e.

$$\delta_k = -\frac{1}{2} \text{tr} \ E \Omega_l$$

We continue the iteration process until we obtain convergence in the estimate values of the parameters $\theta_k$ and $B_k$.

6. Statistical index: Lorenz Curves

The Lorenz curve is one of the most used graphical presentation forms used to express the degree of difference or inequality in the distribution of health services or income since 1905 [7], this curve is drawn in the form of a square whose side length represents 100%. The Lorenz curve is concave from the top, drawn from the lower left corner to the upper right corner, so that a curve can be obtained from the arrangement of sectors from the lowest incoming levels to the highest against the cumulative percentages of the population on the vertical or vertical axis [7, 9]. As follows.

![Lorenz Curve](https://via.placeholder.com/150)

**Figure 1.** the Lorenz Curve.

7. Statistical index Gini coefficient [25, 27, 28]

It is considered one of the important indicators used to measure inequality in the distribution of services. This indicator is characterized by its ease of use and calculation. Its name is attributed to the statistical scientist (C. Gini) in 1912 [7]. It represents an overall measure of inequality and can be calculated by

$$G = \frac{1}{2} \sum_{i=1}^{k} \left( \frac{x_i}{\sum_{j=1}^{k} x_j} \right) \left( \frac{x_{i+1}}{\sum_{j=1}^{k} x_j} \right)$$
dividing the area between the Lorenz curve and the iso-line by the total area below the perfect iso line, and its value ranges from zero (in the case of absolute equality in the distribution of services) and the correct one (in the case of absolute inequality in the distribution of services). [9], whenever the value of the Gini coefficient approaches zero, this means that the distribution of services is more equitable, and vice versa, the closer its value to one, this indicates the great disparity in the distribution of health services and there are a number of mathematical formulas through which the Gini coefficient can be calculated.

\[
G_i = \frac{1}{10000} \sum_{i=1}^{n} \left( S_i + S_{i-1} \right) W_i
\]

Where: \( G_i \) is the Gini coefficient, \( S_i \): the rising combined frequency of the class (i) spending ratio. \( S_{(i-1)} \): the rising cumulative frequency of the percentage of previous category spending (i). \( W_i \): the percentage of the number of individuals category (i). \( n \): the number of individuals or the size of the community [9].

8. Collecting data

To identify the strengths and weaknesses in the distribution of health services in Wasit Governorate, which includes government hospitals and health centers (whether they are hospitals, health centers or health homes) and their medical staff represented by pharmacists, and then come up with the best distribution of health services that take into account the needs of the local community. The data was analyzed by comparing the first, second, and third-degree trend surface models and based on the spatial distribution criteria for health services in terms of the number of hospitals and health centers available or located in the center or districts and sub-districts of Wasit Governorate. Where the analysis was based on the survey conducted by the researcher for health services represented by the cadre of pharmacists under study. And that is within the scope of Wasit Governorate, and we have been provided with data by the Iraqi Ministry of Health (Wasit Health Directorate) according to the data available to them from the number of hospitals, health centers and medical personnel (pharmacists) for the public sector for the year (2018). It was also obtained by the Central Bureau of Statistics on population censuses for all districts and sub-districts of Wasit Governorate for the year 2018. This study included geographical, urban and health aspects with regard to hospitals, health centers and medical clinics in addition to data related to population and their distribution according to the study area. On the other hand, the study relied on the geographical locations of hospitals and health centers where the Gbs program was used to determine the locations accurately. As for the spatial boundaries, they are represented by the administrative borders of Wasit Governorate, which is located in the eastern section of central Iraq, as it is noticed that the governorate is bordered on the north by the governorates of Baghdad and Diyala, and on the south by the governorates of Dhi Qar and Maysan, on the east by the state of Iran, and on the west by the governorates of Babel and Qadisiyah, extending astronomically between the two latitude circles (33-30 -51-54) north, longitude (46-34-44-31) to the east, and its area is (17153) square kilometers, and thus it constitutes (3.9%) of Iraq’s area amounting to (434128) square kilometers. The area of Wasit Governorate is divided into 6 administrative units at the district level, which are Al-Kut district, Al-Nu`maniyah district, Badra district, Al-Hayy district, Al-Suwayrah district and Al-Aziziyah district. Despite the abundance of vocabulary about the health situation that affects it, such as health services, resources, financial matters, etc. For the year (2018) for Wasit Governorate. Despite the abundance of vocabulary about the health situation that affects it, such as health services, resources, financial matters, etc., we could not obtain data except for the number of pharmacists in each district of Wasit governorate and for each hospital or health center, and it was placed in Table (1), which represents the data for the year (2018) for Wasit Governorate.

9. data analysis

Before building any of the spatial inference models, we must determine the spatial location of each health center or hospital. This is by determining the longitude and latitude of each site, and this has been determined by the GBS program.
10. Building a trend surface model

We will build a model of the trend surface of the first, second and third degrees for the number of pharmacists in each health center and hospital where the program (Geo Data) specialized in this was used and using Table (1). Before building the model for this data, it is necessary to choose an appropriate covariance model for this data because the table data (1) cannot be applied directly and has multiple features and because there is a strong relationship between longitude and latitude. Therefore, we must compute the covariance and variance matrix. That is, determine a suitable covariance model. The following covariance model has been chosen.

\[ \sigma_{ij} = \begin{cases} \sigma_i^2 - \sigma_j^2 & i \neq j \\ \sigma_i^2 + \sigma_j^2 & i = j \end{cases} \]

As: \(\sigma_i^2\) represents the observed variation effect, \(\sigma_j^2\) represents the heterogeneity of the spatial effect of the observed. \(\sigma_i^2\) represents the Nugget effect and \(\sigma_j^2, \sigma_j^2, \sigma_j^2\) represent the parameters of the covariance function that must be estimated in order to obtain an approximate covariance model for the data and in order to use it in the prediction process for the spatial random process that represents (the number of pharmacists). Nugget effect is a term in spatial statistics that represents the limit of random error that occurs due to both errors in measurement and other errors that cannot be controlled and affect
the continuity of this spatial phenomenon. When \( i = j \), then \( \sigma_i^2 + \sigma_j^2 \) is the variance in the main diagonal in the covariance matrix, and when \( i \neq j \), then \( \sigma_i^2 - \sigma_i^2 \) represents the covariance that depends on the distance between the \( i \) observation and the \( j \) observation. The covariance matrix \( \Omega \) was calculated:

\[
\Omega = \begin{pmatrix}
698319.9617 & -12722.4849 & -6223.19238 \\
-12722.48967 & 248.28065 & 101.564658 \\
-6223.19235 & 101.564658 & 63.9236
\end{pmatrix}
\]

After finding the covariance function \( \Omega \) we find the inverse of the matrix \( \Omega^{-1} \). Then we estimate the parameters \( \beta \) according to the following formula:

\[
\beta = (X \Omega^{-1} X)^{-1} X \Omega^{-1} y
\]

After using the Geo Data program, the parameters of the regression model of the first, second and third degree are estimated according to the following table:

| No. | \( \beta_0 \) | \( \beta_1 \) | \( \beta_2 \) | \( \beta_3 \) | \( \beta_4 \) | \( \beta_5 \) | \( \beta_6 \) |
|-----|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| first | 43.096 | - | -0.7174 |
| second | -0.0018 | -1351.55 | 976.125 | 14.0303 | -14.197 | 9.5338 |
| Third | 0.01110 | -158606 | 108618 | 9485.5 | -8.7481 | -6477.42 | -130.708 |

Table 2. estimating the parameters of the first, second and third order of the trend surface model.

To determine the best directional surface model, the determination coefficient \( R^2 \) and the corrected coefficient of determination \( \text{Adj } R^2 \) as well as \( \text{Aic}, \text{Bic}, \text{and SE} \) were calculated. For each of the trend surface models, the results are described in the following table:

| Model degree | \( R^2 \) | \( \text{Adj } R^2 \) | \( \text{Sigma-square} \) | \( \text{S.E.of regr} \) | \( \text{Sigma-s-ml} \) | \( \text{S.E.of regr.ml} \) | Aic | Bic |
|--------------|----------|-------------------------|--------------------------|--------------------------|--------------------------|--------------------------|-----|-----|
| M1 | 38 | 0.0005 | -0.0520 | 226.439 | 15.0279 | 209.871 | 14.4869 | 341.559 | 346.7 |
| M2 | 36 | 0.0439 | -0.0888 | 231.151 | 15.2037 | 198.13 | 14.0759 | 353.326 | 363.752 |
| M3 | 32 | 0.0817 | -0.1764 | 249.762 | 15.8038 | 190.295 | 13.7947 | 359.631 | 377.008 |
From Table (4), we find that the best model is m1, which represents the first-degree trend surface model that had the lowest Aic = 341.559 , the lowest Bic = 346.7 and the coefficient of determination value $R^2 = 0.0005$, which represents the ratio of the data interpretation (the number of pharmacists) to the regression, either the sum of squares Errors are SE = 15.0279.

After determining the best trend surface model, which is the first model (m1), which is the first-degree trend surface model, the estimated equation is:

$$\hat{y} = 43.0196 - 0.01609u - 0.71761v$$

From this estimated equation, we can calculate the estimated $\hat{y}$ values and errors, as in the following table:

**Table 5. the estimated values for pharmacists.**

| Sector       | Health facilities   | Phar.$\hat{y}$ | Sector       | Heal. facil.       | Phar. $\hat{y}$ |
|--------------|---------------------|----------------|--------------|-------------------|-----------------|
| first Kut    | Al-Kut first sector | 9.62           | farm         | Essaouira         | 10.34           |
| first Kut    | Taiba Model         | 9.61           | Al-Razi      | 10.35             |
|              | EL-Hussein          | 9.61           | Tabuk        | 10.35             |
|              | Murtaza             | 9.61           | Adiposity    | 10.37             |
|              | Badra               | 9.53           | Essaouira    | 10.37             |
|              | Sheikh Saad         | 9.29           | Azizia sector| 10.39             |
|              | the wise            | 9.59           | Azizia       | 10.38             |
| second Kut   | Al Kut Hospital     | 9.63           | Zubaidiya    | 10.04             |
|              | The second Kut      | 9.62           | Dabouni      | 9.89              |
| second Kut   | Typical jihad       | 9.62           | Tajuddin     | 10.29             |
|              | Howrah              | 9.59           | Azizia Hospital | 10.16          |
|              | M. s. Hakim Dujaili | 9.43           | Numaniya     | 9.90              |
|              | Wasit sub-district  | 9.43           | Free         | 9.79              |
|              | Mazak               | 9.61           | Hajj          | 9.91              |
|              |                     |                | Numaniya     |                   |
|              |                     |                | Hospital      |                   |
|              | Abdullah Ibn Rawaha | 9.43           | Numaniya     | 9.91              |
|              |                      |                | Hospital      |                   |
|              | Youssoufia          | 9.66           | District      | 9.42              |
|              | Karama Hospital     | 9.60           | Unit          | 9.47              |
|              | Essaouira Hospital  | 10.25          | Military      | 9.47              |
|              | Essaouira strip     | 10.37          | Conciliation  | 9.54              |
|              |                      |                | Fayrouz Hospital | 9.47            |

11. Using the Lorenz curve index and the Gini coefficient

By using the Lorenz curve for pharmacists before forecasting on the data in Table (1), the results were shown using the (i-xploer) program as in the following figure
Figure 2. Lorenz curve and Gini index for pharmacists before forecasting.

We notice from the above figure that the health services, in relation to the number of pharmacists, did not lie on an equal line for the optimal distribution, and the curve’s approaching the horizontal is also indicative of the lack of equality in the distribution of health services in Wasit Governorate.

We also note that the value of the Gini coefficient = 0.641, this indicates that there is no equal in the distribution of health services within the governorate by 0.641% because the lower the value of the Gini coefficient, the better the fairness of the distribution. But when using the Lorenz curve and the Gini index on the predicted data ($\hat{y}$) in Table (5)

Figure 3. Lorenz curve and Gini index for pharmacists after prediction.

From the above figure, the Lorenz curve appears, which is very close to the optimum line of health services within the governorate, and this is evidence that there is fairness in the distribution of health
services within the governorate. And that the value of the Gini index is equal to Gini = 0.020, this means that there is no difference in the distribution of health services and the income of the governorate for pharmacists.

12. conclusions

1- The best directional surface model for pharmacists is the first-order trend surface model that had the least Aic and Bic in relation to the coefficient of determination. It showed that the third-degree trend surface model was the best model for having the largest determination coefficient compared to the rest.

2- The Lorenz curve showed the lack of equality in the distribution of services, the preparation of pharmacists in Wasit governorate, and this was confirmed by the Gini coefficient, whose value was 0.64%, which indicates the lack of equality in the distribution of services. The preparation of pharmacists within the governorate either with respect to the data predicted using the trend surface model from First degree, we note that the Lorno curve showed that there is fairness in the distribution of pharmacists within the governorate and that the Gini coefficient has proven that there is no discrepancy in the distribution.

13. recommendations

1- Creating a database for the health services needed by the governorate to enable the researcher to conduct an accurate and realistic study and thus give a picture of the health situation with the need to focus on the financial amounts that the state and the governorate allocate to the health sector, especially Wasit Governorate, and how these sums are distributed within the governorate.

2- Addressing the problem of pharmacists moving to certain sites without others, which is due to the lack of successful planning. The health center must be built and planned as a hospital. Therefore, when appointing doctors in various specialties, especially in health centers, medical devices must be provided for each doctor according to his specialization. This center will turn into a hospital.

3- Establishing a study to find out how to keep pharmacists inside the governorate and not return them to their original governorates by providing housing and facilitating transportation matters, allocating plots of land for them and sums of money and giving them rewards as well as providing protection and this makes the doctor think more than once before he submits the transfer because he may lose things You may not have it out of place.

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