Spatial statistic of reproduction of dengue fever mosquitoes transmitter phenomenon in the university municipality Jeddah Province Saudi Arabia during 2018

Farah Abdallah Mohammed Elhassan [1], Mohammed Alameen Eissa Qurashi [1, *], Mubarak H. Elhafian [2]

[1]Department of Statistics, Faculty of Science, Sudan University of Science and Technology, Khartoum, Sudan
[2]Collage of Science and Arts Department of Mathematics, King Abdul-Aziz University, Jeddah, Saudi Arabia

A R T I C L E   I N F O

A B S T R A C T

Dengue fever mosquitoes transmitter spread in Jeddah Province in the Kingdom of Saudi Arabia as a result of environmental, cultural, and other factors. The concerned bodies are carrying out fighting operations in order to provide a mechanism to concentrate on certain areas and place them as a priority in fighting operations. The objective of this study is centered on examining the spatial methods to know mosquitoes' reproduction patterns and assist the decision-makers in Jeddah Municipality to know mosquitoes' reproduction patterns and the geographical places where they concentrate inside University Municipality. Therefore, it is necessary to know the Municipality pattern in the University Municipality, and the range of spatial correlation availability to the analysis of mosquitoes reproduction spread pattern. The study of mosquitoes reproduction in University Municipality was completed, The data of this study was represented in the number of dengue fever mosquitoes transmitter reproduction during the weeks (1 to 46) in 2018 successively for different districts in University municipality, they are (Al-Thagr, Al-University, Al-Sulaymaniah-al-Ruabi-Al-Fayha) using GPS technology for reproduction pits. The most important finding of the study is that mosquitoes reproduction phenomenon in University Municipality is randomly distributed, and University and Al-Thagr districts are the most districts where dengue fever mosquitoes transmitter are reproduced. We also find that the distribution pattern is not spaced or close or cluster, i.e., not randomly distributed. Out of the most study recommendation is a concentration on "University and Al-Thagr districts" by taking many measurements which limit dengue fever mosquitoes transmitter reproduction in the University Municipality and can be circulated to all districts in Jeddah province Municipalities. The research provides a good tool for the decision-makers and assists them in determining the areas which need fighting operations more than the others.

1. Introduction

The study was conducted in Jeddah, Saudi Arabia. Jeddah is located on the Red Sea coast, latitude 33 230 210, longitude 220 100 390. Jeddah is one of the most populated cities in Saudi Arabia, which has more than 14 municipalities, starting with the municipality of the southern in the south and ending with the municipality of Dhahban in the north

(Hassan et al., 2013). Jeddah is infected with Dengue Fever, where the highest percentage of people with this disease was recorded in 2011 (Khormi and Kumar, 2011).

The first appearance of "dengue fever" was in Asia, Africa, and South America in 1780 (Guzman and Kouri, 2003). It has a special geographical outbreak and transmitted by mosquitoes called "sedeas eagypti." The symptoms of this disease include severe headaches, high fever, joint and muscle pain, rashes with abdominal pain, nausea, vomiting, and diarrhea. Dengue fever may cause death, as the platelet count may continue to decrease as long as the patient is at a high temperature (Ng et al., 2009).

The virus that causes dengue fever is a group of viruses called dengue which transmitted by

mosquitoes (not transmitted by humans), as these mosquitoes reproduce in water stored for drinking or swimming purposes, in the reserved or collected water in the streets, or at air conditioners (La Ruche et al., 2010). The cities of Jeddah and Jizan are among the most cities that recorded the highest rates of infection with this disease, especially with high rates of rain. The Saudi Ministry of Health made a lot of efforts to combat it as well as fighting mosquito breeding environments such as standing water. The presence of dengue disease is linked to the presence of mosquitoes carrying it (sedeas). Although it is difficult to eliminate it, these competent authorities are doing their best to control it and reduce the intensity of its spread (Jamjoom et al., 2016).

The necessity for the spatial statistic of the social, environmental, and other phenomena appeared because it became clear that the place or location in which the data is presented (map and descriptive data) for the phenomena existing in a designated place has an effect. Maybe the reading is taken (non-spatial statistic) from a certain area due to its proximity where the statistic phenomenon appears in a density more than that in the said area (Simpson and Novak, 2013).

Geographical data are like other data. Data distribution is considered the essence of data analysis, whatever their type, Geographical or non-geographical on which the analysis processes are based, such as the distribution of certain patterns or the environmental phenomenon or demographic phenomenon or human conduct in different geographic areas (Goodchild, 1992).

For this reason, the need to know the patterns or forms taken by the phenomenon in a certain geographical place and study its reasons, or is it just a random distribution founded by luck and chance? We need to know the necessary conditions to specify the locations where certain specifications are available. The studies do not include the spatial influence of the environmental phenomena and only become satisfied with their computing, analysis, and circulation without giving attention to the fact that the area may be affected by the environmental factors, population density and other factors which generally assist in the spread of insects which lead to the difference in density from one place to another.

2. Study problem

As mentioned in the introduction, dengue fever is considered one of the serious diseases affecting human health, which may lead to serious complications leading to death.

The main problem with this study is the high prevalence of mosquitoes carrying me dengue fever in the city of Jeddah in general and in the university district in particular. Therefore, it was necessary to conduct surveys and analytical studies that contribute significantly to helping government health agencies to play their part in providing the necessary health care.

Another problem exists in the fact that the descriptive spatial statistic method gives a pattern of the phenomenon increase and does not give an indication for the distribution type, whether it is random or cluster.

3. Proposed solution

This type of study relies on identifying the problem mainly, then identifying the causes of the problem and making appropriate recommendations that include solutions. In order to identify the main cause of the study problem, the following hypotheses must first be tested:

- The distribution pattern of mosquitos' reproduction in the University municipality is random
- The spatial correlation for mosquitoes reproduction phenomenon in University municipality.
- The Distribution pattern of mosquitoes reproduction in the university municipality is moral.

After testing hypotheses that depend on special statistics, which are a special method of analysis, the geographical location (spatial) for mosquitoes reproduction was included in university districts and the range of the location effect on the reproduction phenomenon using the spatial analysis. We can determine spatial scales that greatly help the competent authorities in locating and distributing mosquitoes, and then combating them in a way that reduces the spread of dengue fever

4. The spatial statistics

Non-spatial data descriptive statistic methods are concerned with the calculation of indicators that show the range of agglomeration or dispersion of this data at certain points, which are known as dispersion and central tendency measures, they care only presenting and summarizing a big group of non-spatial data. They can be described by a digital form only through a description of the indicators or statistical dealings which give a form about this data characteristic.

There are indicators and statistical dealings for the description and analysis of the spatial data (geographical locations) of the phenomena as to their spatial characteristics and spatial dispersion. The analysis of the spatial analysis is considered a basic complement of the analysis of the values of the phenomenon itself. Any phenomenon on the surface of the earth needs to be understood to analyze the locations, dimensions, and volumes of its terms spatially. Central tendency measures provide information about the middle or intermediate center of a set of spatial distributions. The positioning of any phenomenon is determined spatially by Fotheringham et al. (2000).

- **Mean Center (X, Y) which is calculated in the following mathematical formula**: Mean Center (X, Y) which is calculated in the following mathematical formula:

$$X = \frac{\sum_{i=1}^{n} X}{n}. \tag{1}$$

$$Y = \frac{\sum_{i=1}^{n} Y}{n}. \tag{2}$$

- **Weighted mean center:** Weighted Mean Center is calculated according to the following mathematical formula:

$$X = \frac{\sum_{i=1}^{n} WX}{\sum_{i=1}^{n} W} \tag{3}$$

$$Y = \frac{\sum_{i=1}^{n} WY}{\sum_{i=1}^{n} W} \tag{4}$$

- **Median center:** Median center is calculated by following the same steps of calculating the medium non-spatial data for each coordinate separately by arranging the coordinates in ascending or descending order then select the value which mediates these coordinates according to the following equations (Webster and Oliver, 2007). In the case of an odd number of coordinates:

$$mod = \frac{N+1}{2}. \tag{5}$$

There is one median value. In the case of even coordinates:

$$mod_1 = \frac{N}{2}, mod_2 = \frac{N}{2} + 1. \tag{6}$$

There are two intermediate values, and the median shall be as follows:

$$\frac{mod_1 + mod_2}{2}. \tag{7}$$

There are also many indicators that indicate the spatial dispersion of the phenomenon in the locations of the terms of a certain phenomenon:

- **Standard distance:** It is considered the corresponding of the standard deviation of non-spatial data and is used as an indicator of the extent of spacing or agglomeration of the values (the points) and is represented as a circle (standard circle) centered in the same position of the average center, and is calculated as follows (Haining and Haining, 2003):

$$SD = \sqrt{((x - \overline{x})^2}/n) + \sqrt{((y - \overline{y})^2}/n) \tag{8}$$

- **Standard distance weighted:**

$$SD_w = \sqrt{\frac{\sum_{i=1}^{n} w_i(x_i - \overline{x})^2}{\sum_{i=1}^{n} w_i} + \frac{\sum_{i=1}^{n} w_i(y_i - \overline{y})^2}{\sum_{i=1}^{n} w_i}} \tag{9}$$

4.1. Directional distribution

It is an oval shape (Ellipse) that expresses the properties of a directional distribution.

The center of this oval shape shall be applicable to the middle center showing the direction of the distribution of terms. Its larger center measures the value of the direction taken by most values of the phenomenon, based on the direction of the rotation (Yager and Hopkins, 1993).

$$\sigma_{1,2} = \frac{(\sum_{i=1}^{n} x_i^2 + \sum_{i=1}^{n} y_i^2 \pm)\sqrt{(\sum_{i=1}^{n} x_i^2 - \sum_{i=1}^{n} y_i^2)\sum_{i=1}^{n} x_i^2 + 4(\sum_{i}^{n} x_i y_i)^2}}{2n} \tag{10}$$

To test the randomness of the distribution between the studied phenomenon points and to compare the distribution patterns for more than one area, the following criteria were used

4.2. Nearest neighbor or neighborhood relation

It is considered a common method of spreading and used by geographers. Its idea is based on giving a rough judgment of the spacing between points, aiming to reach a quantitative criterion to infer the spatial pattern distribution of the centers represented by these points and the nearest neighbor equation can be formulated as follows (Prasomphan and Mase, 2013):

$$R = 2x\sqrt{\frac{m}{n}} \tag{11}$$

where, R is the nearest neighbor; X is the distance rate (total distance/number of distances; M is the number of points; n is total distance.

The nearest neighbor coefficient (R) expresses the distribution pattern, and its value ranges between (0≤R≤2.15). Accordingly, three patterns of the main spatial distribution are specified with other patterns near to it, the patterns are.

4.2.1. Convergent distribution pattern

The value of the coefficient 0<R<1 is such that R=0, the phenomenon point, in this case, is grouped in one location.

0>R>0.5 the pattern, in this case, shall be convergent, and the closer to zero, it shall be more convergent, and the distribution pattern of data shall become in the form of a cluster (clustered).

If the value of R1 is 0.5, the pattern is convergent and moves towards the random pattern (Aiba et al., 2013).

4.2.2. Randomization distribution pattern

The value of the coefficient R=1, the random pattern, is a purely theoretical pattern, and there is no distribution of geographic phenomena on the surface of the earth that takes this pattern (Dixon, 2006).

4.2.3. Spacing distribution pattern

The values of the nearest neighbor coefficient range from (1<R<2.15), so that if the value of R>1 is

2, the pattern shall be spaced unorganized, and if (R=2) the divergent pattern shall be in this case resulting from a regular distribution of points. Their shape shall be square shape so that the closer the R-value to 2.15, the greater the spacing between the distributing points. When the points are at their maximum spacing, their distribution shape, in this case, shall take the shape of a hexagon (Byers, 1984).

4.3. Spatial auto-correlation coefficient (Moran index)

Statisticians experts use the spatial auto-correlation coefficient in the measurement of the similarity of contiguous phenomena, which depend on comparing the value related to each parameter with the average value of the structure, which is called the statistical value (Moran Index) (Teixeira and Cruz, 2011).

In this method, if the difference between the adjacent values is smaller than the difference between all the parameters, similar values are aggregated. Geographical phenomena are normally associated with the values of spatially adjacent variables. When the values of a variable in a location are associated with the values of the same variable in a nearby location, this shows a self-correlation between the two variables is sometimes referred to as neighborhood effect or Contiguity. Here we ask, are similar phenomena in the place gather? Generally, the spatial self-correlation coefficient measures simultaneously the similarity between the spatial elements locations and their distinguishing characteristics, and it can be calculated according to the following mathematical model:

$$I = \frac{N}{\sum_1^i \sum_1^i Wij} \frac{\sum_1^i \sum_1^i Wij(x_{i-\bar{x}})((x_{j-\bar{x}})}{\sum_1^i (x_{i-\bar{x}})^2} \qquad (12)$$

where, Wij is the spatial weight between i and j; N is the total number of terms.

Moran index is considered one of the important measures in detecting the self-correlation between the elements of the studied phenomenon and assess its spatial distribution pattern, is it dispersed or regular or random pattern?

The value of the index ranges between (1-) to (+1). If the index value is near to (+1), this indicates that the pattern is random, while the pattern is described as regular if its value reached zero or close to that.

The distribution pattern varies between grouping, regularity, and randomness, depending on the index value.

The general framework for testing the hypotheses is considered a good outcome tool to judge the nature and pattern of the spatial distribution for the geographical phenomenon. Especially, the results of the measures used within the program (ArcGIS 10.3) depends entirely on the principles of testing hypotheses (Almeida et al., 2009).

The issue necessitates first determining the initial hypothesis (nullity hypothesis) or the zero hypotheses, which stipulates that there is no existence of a particular pattern of distribution, and the expected pattern is a random pattern produced by the act of chance or luck. In order to decide whether to accept or reject the above hypothesis in case of using the coefficient, the zero theory recognizes that there is no aggregation or spatial agglomeration for the values of the geographical phenomena

5. Test of distribution pattern significance

The assurance shall be made that the differences are significant, and the distribution pattern has a statistical index. Turning to Z test or the standard degree

$$Z = \frac{A-B}{\frac{S}{\sqrt{N}}}. \qquad (13)$$

where A is the real rate of distance; B is the theoretical rate of distance; S is standard deviation; N is a number of points.

The value of (Z) is found from the statistical tables where it is extracted and below the level (0.9, 0.95, 0.99) and the degree of freedom (n-1).

If the calculated Z value is less than the tabulated, the zero hypotheses (H0) shall be rejected, i.e., the significant differences have a statistical index, and the distribution of distances is not random, but if the opposite, i.e., the calculated differences are more than the tabulated ones and the distribution of distances shall be random. But when the value of (P) is small, and the absolute value of (Z) is so great that it falls outside the required confidence level, if the value is less than (0), then the group of phenomena appears in a diverging form (Campbell and Clarke, 1971). Fig. 1 shows possible R values based on the number of points.

6. Results and discussion

6.1. Data set

Daily data for mosquitoes reproduction were collected during the weeks (1-46) successively during 2018 for different University districts (Al-Thagr, Al-University, Al-Sulaymaniah, Al-Ruabi, Al-Fayha) using GPS technology for mosquitoes reproduction pits during the said period. Fig. 2 shows mosquitoes distribution.

Spatial analysis in the GIS environment depends on the spatial characteristics of the phenomena sites under analysis. The spatial characteristics of any layer (Shapefile) are represented in determining the type of used coordinates in the spatial signature, the type of used projector, as well as the earth model (reference) used in the layer.

The researcher used the ArcGIS program because the program provides the possibility of non-spatial statistical analysis and spatial analysis of the data

collected about the reproduction of mosquitoes in
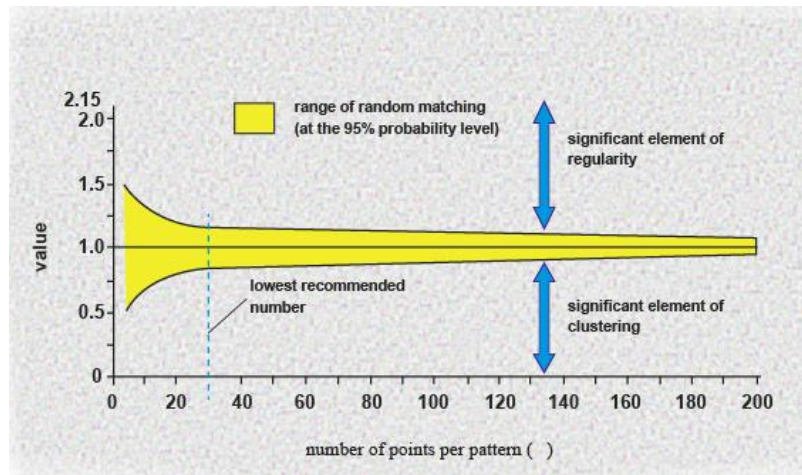
the university municipality as follows.

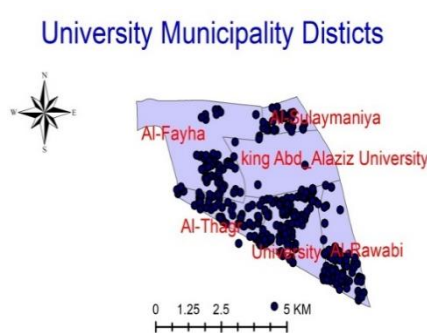**Fig. 1:** Possible R values based on the number of points

Fig. 2: Mosquitoes distribution in university municipality

6.2. Descriptive statistics

Table 1 shows middle calculation and standard deviation more value and less value for the variable of the number of mosquitoes reproduction in university municipality districts:

Table 1: Non-spatial descriptive statistic for university municipality district

District	Average	Standard deviation
Al-Thagr	31,7975	264,1377
University	19,761	91,3084
Al-Rawabi	147925	20,1250
Al-Sulaymaniya	18549	27,3815
Al-Fayha	119719	11,9091
Districts total	206467	140,9667

Table 1 shows that the highest mosquitoes reproduction in the standard deviation university districts is Al-Thaghr where it reached (31.7975) with (264.1377), and then the university district where the average is (19.671) with (91.3084), standard deviation while we find Al-Fayhaa district having the lowest average among the university municipality districts where it reached (11.9719) with a standard deviation of (11.9091), and the average total districts reached (20.6467) with a standard deviation of (140.9667).

6.3. Spatial statistics

Necessary practical methods for entering data into the ArcGIS program are followed, then spatial

statistics to describe them spatially were performed and then the answer of the formulated hypotheses, as follows.

6.3.1. Mean center

The mean value of the two coordinates reached (39.244702, z=20.660761=y=21.480965, x) by following the same steps of the normal calculation but for each coordinate separated from the other.

The value at this point is (20.660761), which is located inside the university district. Fig. 3 shows the mean center in the university municipality.
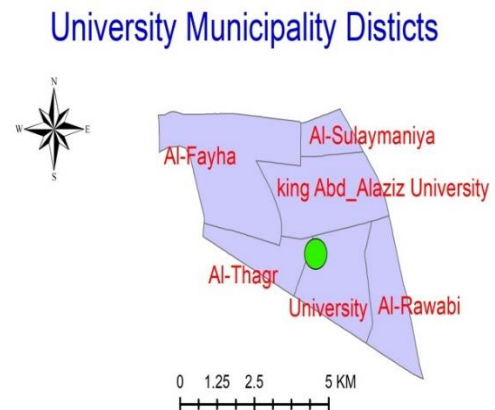

Fig. 3: Mean center in university municipality

6.3.2. Weighted mean center

same steps of the middle position were followed, but the number of mosquitoes was chosen as the weight with the middle center, and the result was (21.480224, Z=982.82=X=39.244379, Y), which means that there is a difference in the weighted average center compared to the center, where the value of Z reached at this Point (982.82) inside the university municipality.

It is clear from the shape of the Fig. 4 that the weighted mean of mosquito reproduction is located inside the university district near the Al-Thaghr district.
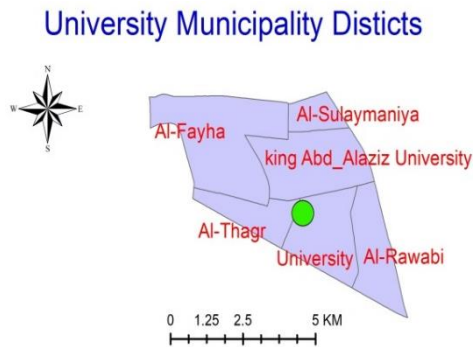
Fig. 4: Weighted mean center in university municipality

6.3.3. Median center

All steps by which the median for non-spatial data is calculated are followed by arranging the variables ascending or descending and then calculating the median. However, for spatial data, each coordinate is calculated separately, and the spatial median of the university municipality districts is (21.47878=X=39.242065, Y), as shown by Fig. 4.

It is clear from Fig. 5 that the location of the median is at the separating point between the university district and Al-Thagr district, and the bigger part of it is located inside the university district.
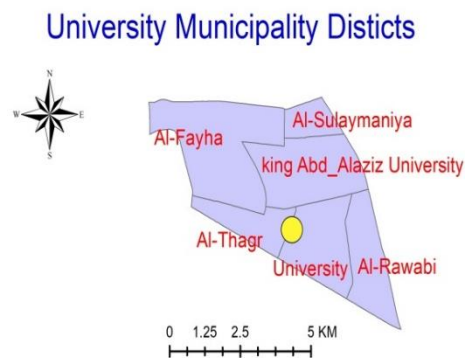

Fig. 5: The median center in university municipality

6.3.4. Standard distance

The standard distance value was calculated as in Table 2.

Table 2: Standard distance of mosquito reproduction in the University Municipality

y Centre	x Centre	Standard Dist
21.480224	39.244379	0.017077

Table 2 shows the value of the standard area for a small semi-circle is, which means that there is no dispersion in the f mosquitoes reproduction, and there is convergence in places of mosquito reproduction in the university municipality districts. i.e., spread in a convergent geographical locality.

It is clear from the shape of Fig. 6 maps that the shape of the standard distance circle is widespread within the districts (university, Alt-Thagr), which means there is convergence in reproduction.
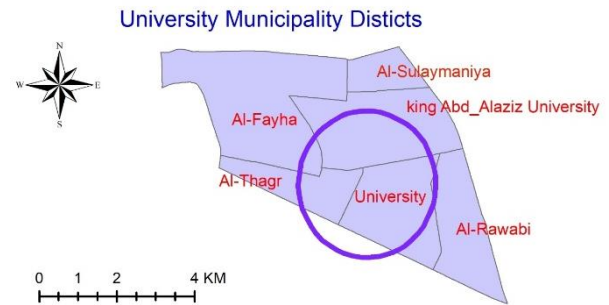

Fig. 6: The standard distance of mosquito reproduction in the university municipality

6.3.5. Distribution direction

Table 3 shows the distribution direction statistics.

Table 3: Distribution direction of dengue fever mosquitos transmitter in university municipality

Centre X	Centre Y	XStdDis.	YStdDis.	Rotation
39.244379	21.480224	0.020441	0.012861	120.6789

Table 3 shows the coordinates of (x, y) as well as the radius of the standard distance in the direction of the coordinate (x Std. Dist.=0.020441) and the radius of the standard distance in the coordinates (y Std. Dist.=0.012861). We find that each value is small and the difference between them is small which means that the direction is about to take the form of a circle, we also find that the rotation value reached (120.6789) and this value is located between the North and West directions (angle 90 and angle 180), which means that the direction of the rotation takes the direction towards Northwest and that the extensions of this rotation are heading Southeast.

It is clear from the shape of Fig. 7 that the distribution direction of mosquitoes reproduction sites is distributed in the South-West direction inside the university municipality, and these extensions are located inside the university and Al-Thaghr districts, and in small parts in each of (Al-Rawabi and Al-Faiha districts).
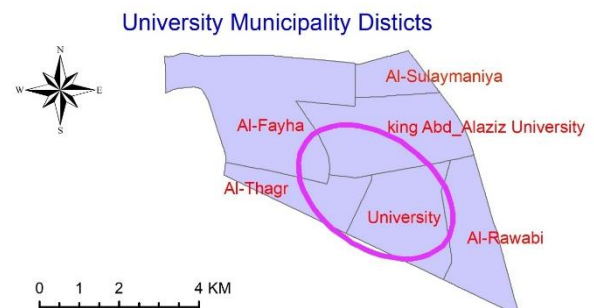

Fig. 7: The distribution directions inside the university municipality

6.3.6. Hypothesis testing

Patterns analysis represented in the nearest neighbor analysis and Moran I analysis was used.

- **The first hypothesis:** There is a spatial correlation of the mosquito reproduction phenomenon in the university municipality. Moran I statistic was calculated as follows:

  ➤ Zero hypothesis: The phenomenon of mosquitoes reproduction is not spatially correlated (Randomly distributed).
  ➤ Alternative hypothesis: The phenomenon of mosquitoes reproduction is spatially correlated (Non-randomly distributed.

Table 4 shows the results of the Moran I test, which is provided by the ArcGIS program according to the following Table 4.

Table 4: Moran test

Global Moran's I Summary	
Index Moran's I	0.006435
Expected Index	-.000377
Variance	0.000006
Z-score	2.769585
p-value	0.005613

Based on the p-value (less than 0.01), we reject the zero hypothesis and accept the alternative hypothesis. This indicates that the spread of mosquitoes in the university municipality is (Non-randomly distributed. Fig. 7 shows these results. Fig. 8 shows the spatial autocorrelation report.
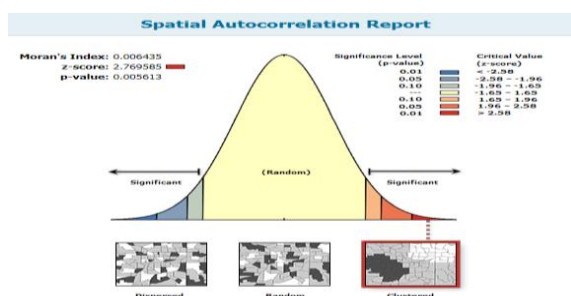

Fig. 8: Spatial autocorrelation report

Through the index expressed for as Ratio between the observed or calculated distance divided by the expected distance, where the expected distance was based on a random distribution assumption by a similar number of points distributed over the same geographical area and since the index reached (-0.000377) less than one whole number, the geographical distribution of mosquito reproduction sites (Cluster). We also find the calculated Z value (2.769585) is greater than the (-2.58) and also the value of the calculated statistical index reached (0.005613) which is less than (0.01) which means acceptance of the alternative hypothesis, i.e., the phenomenon of mosquito reproduction in the university municipality districts is clustered.

- **The second hypothesis:** The distribution pattern of mosquitoes reproduction phenomenon in the university municipality is random (spaced).

  ➤ Zero hypothesis: Spaced distribution pattern (non-clustered-random)
  ➤ Alternative hypothesis: Non-spaced distribution pattern (clustered–random).

Table 5 shows a p-value of less than 0.05. This indicates that we will reject the Zero hypothesis and accept alternative hypothesis (there is clustered in mosquitoes' spread at the university municipality. Fig. 9 shows the result of the average nearest.

Table 5: Nearest neighbor results

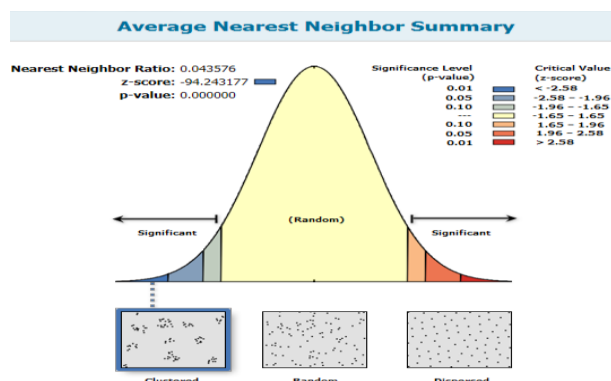| Average Nearest Neighbor Summary	
Observed Mean Distance	2.709136
Expected Mean Distance	62.170181
Nearest Neighbor Ratio	0.043576
Z-score	-94.243177
p-value	0.00000

Fig. 9: Result of average nearest

This result means that the calculated mean of mosquitoes reproduction is less than the expected mean of the same geographic area (random distribution).

This result means that the calculated mosquito breeding rate is lower than the expected average breeding rate in the same geographical area (random distribution).

i.e., Means that the Index is expressed as a ratio between the observed distance or the calculated divided by the expected distance, where the expected distance depended on an assumption random distribution by a similar number of points distributed over the same geographical area and as the index reached (0.043576) less than one whole number, the geographical distribution for mosquitoes reproduction is a cluster. We also find the calculated Z value (2.769585) is greater than the (-2.58), and also the value of the calculated Z reached (-94.243177) which is more than (-2.58), and also the value of the calculated statistical index reached (0.00) which is less than (0.01) which means acceptance of the alternative hypothesis, i.e., the phenomenon of mosquito reproduction in the university municipality districts is clustered.

- **The third hypothesis:** The mosquito breeding phenomenon follows Log-logistic distribution.

  ➤ Null hypothesis: Mosquito breeding phenomenon not follows Log-logistic distribution.

➤ Alternative hypothesis: Mosquito breeding phenomenon follows Log-logistic distribution.
We use Easy-Fit software, as follows in Table 6.

Table 6: Kolmogorov-Smirnov test

Sample Size		682		
Statistic		0.04106		
P-Value		0.19501		
Rank		1		
α	0.2	0.1	0.05	0.02	0.01
Critical Value	0.04109	0.04683	0.052	0.05813	0.06238
Reject?	No	No	No	No	No

Kolmogorov–Smirnov p-value (0.195101>0.05), this indicates that we accept alternative hypothesis mosquito breeding phenomenon follows Log-logistic distribution. Fig. 10 shows a mosquito breeding phenomenon distribution.

6.3.7. Validation

A few studies were shown in Table 7, concerned with the topic of propagation of dengue mosquitoes, whereby patients and injuries were treated and classified. To verify the results and compare them with the previous studies in this field, the results compared with a study made in Carians North Queensland Australia 2014 (Azil et al., 2014).

7. Conclusion

From the reality of the spatial analysis conducted for the mosquitoes reproduction data in the university municipality districts, it became clear that: the number of mosquitoes is denser in the districts (University and Al-Thagr), the spatial mean is located inside the university municipality. The mediator is located in the separating line between (university and Al-Thagr), and the bigger part of the mediator location is located inside the university district. The results also showed that the standard distance for mosquitoes reproduction locations in the university municipality is distributed on a non-verging range since the diameter of the standard distance circle is located inside the districts (university and Al-Thagr). It became clear from the

Directional Distribution results that the radii in the X and Y coordinates are very small, and the rotation rate is moving towards North-West i.e., towards the districts (university and Al-Thsgr).The results of the statistics of both the nearest neighbor and Moran I showed that the distribution pattern of mosquitoes reproduction is convergent or clustered.
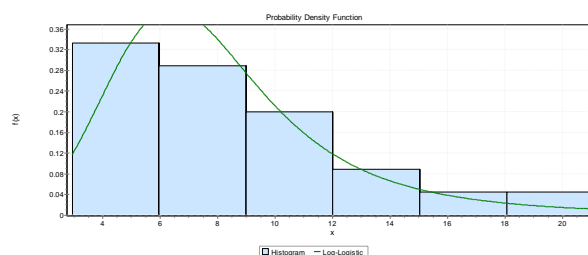
Fig. 10: Mosquito breeding phenomenon distribution

The results of spatial analysis of the phenomenon of mosquitoes reproduction in the university municipality concluded that mosquitos are more spreading in (university and Al-Thagr) districts, and that may be due to the high population density. The two districts are from the old districts and suffer from problems in the sewer system and general lack of planning. Therefore, the Mosquitoes fighting Department must concentrate on (university and Al-Thagr) districts when it is carrying out mosquitoes control operations. The study recommends the following: Fighting the factors which lead basically to mosquito reproduction, such as sewage systems maintenance fighting water leakage through water storage fighting. As it became clear that many of these areas' populations are storing water for use when the water supply is interrupted for several days, which contributes to mosquito reproduction Enact punitive laws and legislation against those who are proved that they help in water leakage.

In future studies, the study can be developed to include all cities of the Kingdom of Saudi Arabia, which contain the most cases of dengue fever. Also other statistical methods can also be included in the study of the phenomenon of transmission and reproduction of mosquitoes carrying dengue fever.

Table 7: Validation

The Measure	The previous study BG2010	The previous study SO2010	The previous study BG2011	The previous study SO2011	The current study of our paper
Observed mean distance (m)	39.8	39.8	47.3	43.9	2.709136
Expected mean distance (m)	34.2	34.2	45.7	40.9	62.170181
Nearest neighbor ratio	1.163	1.163	1.036	1.075	0.043576
Z-score	1.467	1.467	0.333	0.789	-94.243177
P-value	0.142	0.142	0.739	0.430	0.00000
On the distribution of traps	Random	Random	Random	Random	Non-Random
Moran's I Index	0.386	0.144	0.062	−0.096	0.006435
Expected Index	−0.048	−0.048	−0.043	−0.034	-.000377
Z-score	1.996a	0.866	1.021	−0.707	2.769585
P-value	0.046a	0.386	0.307	0.480	0.005613
Significantly different from random distribution (significant at P < 0.10)	Yes	No	No	No	Yes
Spatial pattern	Clustered	Random	Random	Random	Clustered

Compliance with ethical standards

Conflict of interest

The authors declare that they have no conflict of interest.

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