

An Effective Study of Geographical Pattern and Intensity of Dengue Epidemic among Females in Punjab, Pakistan

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Abstract: Introduction: An emerging issue all over the world, especially in the tropical countries, is dengue fever now a day. It is a viral communicating disease which flows from one person to other through female mosquito is known as *Aedes aegypti*. In the short time, its outburst ruins the human and financial resources. Most of the countries with limited technical infrastructure are unable to fight with this disease in a proficient way. **Methodology:** Geographical Information System (GIS) is a smart way to express Epidemiological information in the form of thematic maps which represent geographical pattern and intensity of outbreak. **Result & Conclusion:** In this research study, we used ArcView tool to express female patient's data of Dengue outbreak in 2011. Almost seven thousand females were affected due to Dengue fever in Punjab Province in thirty-seven epidemiological weeks from March 2011 to December 2011. Our research revealed Geographical Pattern and Intensity of Dengue fever among females of all ages in Punjab province. It can assist administrative authorities and health departments for future awareness and preventive measures to take in time action to save human and financial resources.

Keywords: Dengue Fever, GIS, *Aedes aegypti*, Health surveillance, Outbreak

Introduction

Dengue Fever (DF) is a global communicating disease which affected about 3.6 billion individuals from 125 tropics and subtropics countries[1]. There are three types of dengue fever known as Dengue Fever(DF), Dengue Hemorrhagic Fever (DHF) and Dengue Shock Syndrome Fever(DSS) ranging from normal fever to severe bleeding through gums and nose[2]. World Health Organization classify these three types as, Dengue with a warning, Dengue without a warning and severe Dengue. Most of the casualties caused by Dengue virus are associated with DHF and DSS because these are intense forms of Dengue Fever[3]. The ratio of Dengue cases to Population was thriving in ascending order like 44.3/100,000 in 1999 and improved to 181/100,000 in 2007, it was the alarming situation for government in Malaysia[4]. Dengue virus is injected to human by the female mosquito, *Aedes aegypti*, and patient start suffering from temperature more than 38.5 °C along with vomiting, joint pain and headaches[5]. Sometimes a person affected by Dengue virus don't know that he/she is actually suffering from Dengue Fever due to his/her strong immune system[6]. This period stays for 3-7 days, most of the patients recover without any complications[7]. Normally 10,000 casualties occur each year due to severe Dengue

Fever, while two-thirds of the population resides in the geographical area where this disease is widespread. still, now there are no licensed antivirals for Dengue Fever even not in the clinical process[8]. It is estimated that 50 millions of individuals suffered from Dengue Fever infection, 500,000 people suffer from DHF and need hospitalization all over the world [9].

Dengue Fever Symptoms

Dengue Fever starts from mild to severe by causing a high temperature, flu-like illness along with vomiting, headache, blood through, nose, mouth, and gum. The incubation time of virus ranges from 3-14 days [10]. The body temperature of patient rises in short time to 40°C and heartbeat remains low. The temperature stays with fits along with other worries from 2-7 days [11]. There is no certified solution or vaccine, but precautionary measures are the ultimate factor to avoid from the virus. It is better for the patient to use liquid to avoid dehydration [12].

Geographical Information System

Geographical Information System is used to capture, store and manage the geographical information to represent it in thematic maps. It can be used in the different field where spatial information is required like hypsography, hydrography, transmission, waste management, irrigation, crops etc [13]. Data can be represented in multiple layers in the same thematic map, the user can execute required layers, it can be a single layer or multiple layers. GIS plays a significant role in developing a surveillance system for any communicating disease [14]. Administrative authorities and Govt Agencies can be well aware of any outbreak in advance to avoid any troublous situation [15]. GIS can be implemented for future combat with communicating diseases to reduce the economic and human loss.

Literature Review

“GIS-based Dengue surveillance system with Google internet real-time mapping” was designed by in 2014 [10]. Dengue cases occurred across India in 2012 were shown by thematic mapping of Indian map. Geographical regions distributed with the help of diverse colors reflecting intensity level of Dengue cases, and causalities represented by a vertical bar. One inch bar reflects 100 causalities; light grey color reflects Dengue patient less than 25 and red-brown color reflects highest intensity level [17]. Latitudinal and longitudinal addresses of Dengue patients are collected directly in the field by using GPS device whose normal accuracy was about 100 meters. In this model, multiple regressions used which shows relationships between parameters concern to breeding sites and transmission of Dengue fever.

Many cases of Dengue fever reported in Brazil in different cities in 2014. Most of the municipalities have tropical and sub-tropical climatic conditions which favor Dengue to flourish during the warm, humid and drizzly season in densely populated areas. Some attributes are significant in Dengue epidemics like virus flow, human vulnerability, and mosquito abundance [18]. Climatic forecast provided a chance to anticipate Dengue epidemics some months in advance. This model was deployed to predict Dengue threat during 2014 world cup in Brazil in the massive congregation of more than 3 million worldwide and Brazilian audiences [19]. For the development of prediction model, a collaboration with three departments urgently made as a public health authority, mathematical expert, and meteorological authority. Data provided by these authorities was incorporated as periodic weather forecast and epidemiological data into proposed model several months before of event and presented results in an understandable format for stakeholders [20]. Scenario reflected that all twelve municipalities were at low threat,

but high chances of the outbreak were in northeastern cities of Natal, Recife, and Fortaleza. This early warning system helped the health ministry and local authorities in proper implementing and control actions before three months of world cup event[21]. Early warnings disseminated to visitors traveling to Brazil and the general public. This model performed well than average long-term distribution in all twelve cities which host World Cup venues, especially in the northeast region.

Mapping and estimation of Dengue and Chikungunya designed in 2015 by using geographical information system in Central American country Honduras. GIS Kosmo Desktop software used for thematic mapping presented in this research study. Overall 19289 Dengue cases registered, 85386 cases of chikungunya registered with a median of 726 patients of Dengue and 1460 patients of chikungunya per week during 2015. Maximum patient's registration slots were 25th and 27th weeks respectively. National Dengue and chikungunya patients rate were estimated about 224.9/100,000 and 995.6/100,000 patients [22]. Epidemiological maps developed by GIS-assisted decision-making authorities to take action for prevention and control of a disease that still shows major issues in the country.

By deployment of Analytical Hierarchy Process (AHP) in GIS, an analytical tool for Dengue risk assessment designed in Malaysia 2016. The medical database was operated for this research study and arranged in the hierarchical structure[23]. Calculations of relative weights of factors made within a suitable range where consistency percentage was less than 0.1%[24]. The results exposed by AHP based Dengue fever risk area developed substantial information of diverse risk stages. Valuable results gained through this research study can enhance public health initiatives[25]. Spatial analytical approach with GIS applied to surveillance strategies of Dengue fever and supplementary transmissible diseases as an effort for effective control and prevention.

Three months real time Dengue forecasting model was designed by Yuan Shi in 2015. It was developed to predict the evolution of Dengue eruption in Singapore to provide early warning of the outbreak and facilitate public health[26]. It can provide forecasting information per week basis up to three months by processing data taken from three main sources as surveillance data, demographic data and weather data[27]. Surveillance data comprised of Dengue data and breeding percentage. Weather data is comprised of humidity and temperature while demographic data represent the population. Singapore experienced an outbreak in 2013 due to varying ecology, demography, rapid urbanization and rainforest climate which results in 22170 expires. There was no vaccine in the market, so the best approach for prevention was vector control. So for forecasting the evolution of Dengue outbreak in Singapore, this early warning system was developed to facilitate public health and moderate a forthcoming outbreak. In this research studies, a regression analysis method (LASSO) least absolute shrinkage and selection operator method is used to enhance the prediction accuracy along with other statistical methods[28]. This system predicts Dengue incidence report per week up to three months. This system uses multiple sources data like meteorological data, current case data, vector surveillance data and population-based national statistics. Forecasting methodology was compared to substitute approaches, but LASSO proved the excellent one that provided a more precise prediction as compared to previously published methods that evaluated.

Study Area and Data Collection

Pakistan is a sixth populated country in the world with rich agricultural resources. It is comprised of four provinces, Punjab is our study area and most populated province which hold 101.4 millions of population with an

area of 205,344km² and located at (30°55'59.63" N/73°46'22.72" E).Five rivers flow through Punjab which makes it rich agricultural region. It is distributed among 36 administrated boundaries[29].

In this research study, we have used the data collected from all district hospitals of Punjab in 2011.It is a collection of almost 6700 females records registered in district hospitals, while 87% records belong to the capital city of Punjab, Lahore.data set carries the attributes like data, age, sex, city, status, address, IgM, and IgG.



Figure 01: Study Area of Punjab

Figure 01 reflects our study area, the most populated province of the country, Punjab[30]. It is financial hub of Pakistan with agriculture, textile and sports resources.

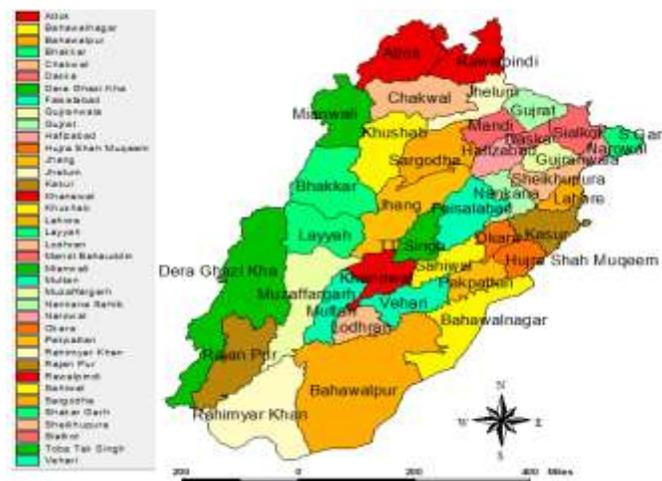


Figure 02: Administrative boundaries of Punjab

Figure02 shows administrative boundaries of Punjab Province. Each geographical patch is discrete to understand the district geographical area. We will reflect geographical pattern and intensity of Dengue female patients through these administrative boundaries.

Data Analysis

In this research study we used data from almost 6700 female registered patients, it is collected from all districts of Punjab. While 5800 females patients are just from capital city Lahore. We have distributed data month wise so that we can analyze the geographical pattern and intensity of each month. We have Pakistan map with three layers, the third layer defined administrative boundaries of districts. We used the third layer for this research study, female registered patients are represented with pink color, and a variation of color reflect the intensity of Dengue Fever with respect to the number of patients.



Geographical Pattern and Intensity of Dengue Virus among Females in March

Figure 03: Geographical Pattern and Intensity in March

Geographical Pattern and Intensity of Dengue in March

Figure03 shows pattern and intensity of Dengue virus, Lahore is the only geographical area which is under dengue attack. It proved a launching pad for Dengue virus, March is not the favorable season for Dengue growth. Dengue virus arrived from Thailand to Lahore when some used tyres were imported. In this way, Lahore proved the initial point and later on the hub for Dengue virus.



Geographical Pattern and Intensity of Dengue Virus among Females in April

Figure 04: Geographical Pattern and Intensity in April

Figure 04 shows pattern and intensity of Dengue virus in the month of April. Whole Punjab reflects Dengue free geographical area except Lahore. If we compare this thematic map with previous one, no change in the geographical pattern but the intensity is slightly lower down. It is due to changing the environment, in April heat get the start and restrict *Aedes aegypti* activities. In result, Dengue is back to its den and wait for suitable meteorological factors.



Figure 05: Geographical Pattern and Intensity in May

Figure 05 shows pattern and intensity of Dengue virus in the month of May. The thematic map reflects that geographical pattern is inconsistent form since March but intensity fluctuation can be observed as it is identical as in the march. May is moving toward more heat, minute chance to spread the virus.



Figure 06: Geographical Pattern and Intensity in June

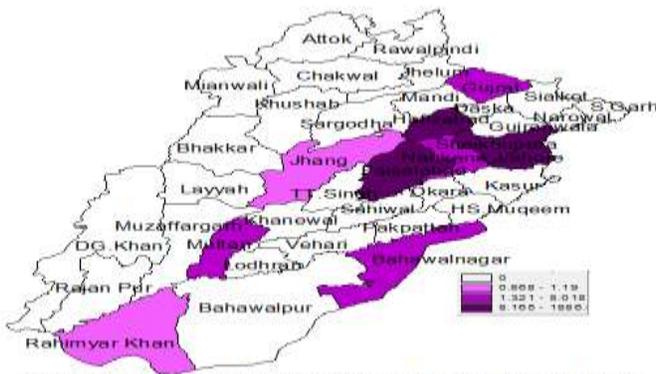
Figure 06 shows pattern and intensity of Dengue virus in the month of June. The thematic map shows that adjacent city Kasur is now under influence along with Lahore. Now Lahore and Kasur are influential geographical areas in Punjab while rest of the administrative areas are in the peaceful environment.



Geographical Pattern and Intensity of Dengue Virus among Females in July

Figure 07: Geographical Pattern and Intensity in July

Figure 07 shows pattern and intensity of Dengue virus in the month of July. Now Dengue virus moved from Lahore to Attock and finished from Kasur. Dengue virus moved to Attock by a female patient, otherwise the area of influence of mosquito is 2-3 kilometers. The main reason of Dengue spread is the transportation of patients or the container which carries larva of Dengue. In all previous thematic maps Lahore in the consistent influential geographical area. In Pakistan June and July are the months with most of the heat, restrict Dengue activities to a minimum level.



Geographical Pattern and Intensity of Dengue Virus among Females in August

Figure 08: Geographical Pattern and Intensity in August

Figure 08 shows pattern and intensity of Dengue virus in the month of August. This month changed the epidemiological scene of 26% geographical area of the province. It is due to climatic change, August is starting month for Monsoon rain in result temperature lower down, humidity is high and rain is reasonable, it is most suitable climate for Dengue to execute its activities. Four layers reflect the pattern and intensity of Dengue, the

first layer reflects that 74% geographical area is Dengue free zone, the second layer reflects Jhang and Rahimyar Khan are suffering from low-level Dengue attack. Third layer show Multan, Nankana and Bahawalnagar at high intensity. The fourth layer reflects the highest intensity and hotspot areas like Lahore, Faisalabad, Sheikhupura, and Hafizabad.

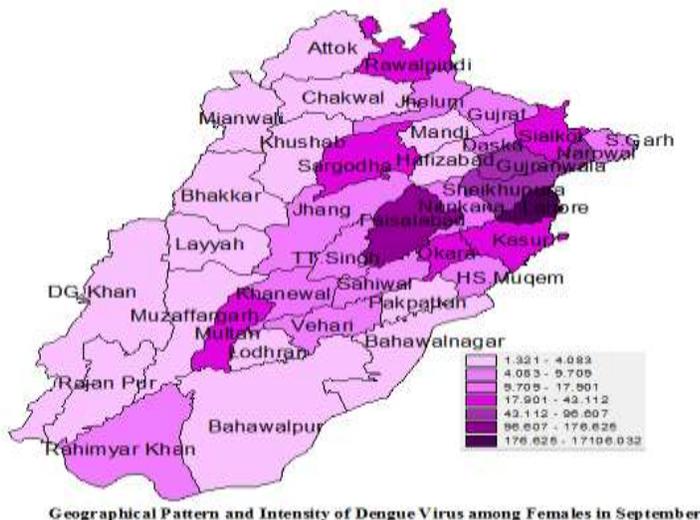


Figure 09: Geographical Pattern and Intensity in September

Figure 09 shows pattern and intensity of Dengue virus in the month of September. No Dengue free zone, a thematic map is fully under the influence and abrupt Dengue outbreak covered the whole geographical area. Seven layers classify the current situation of thematic map 40% geographical area is at a marginal level, 29% is at a low level, 17% high level and 14% highest level hotspot area. In September Lahore, Sheikhupura, Narowal, Faisalabad were hotspot areas.

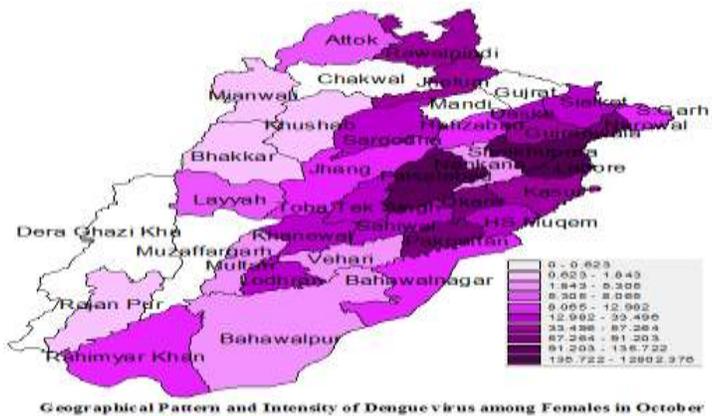
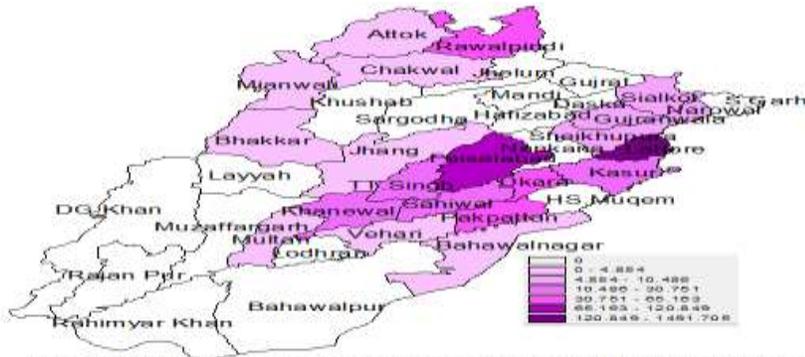


Figure 10: Geographical Pattern and Intensity in October

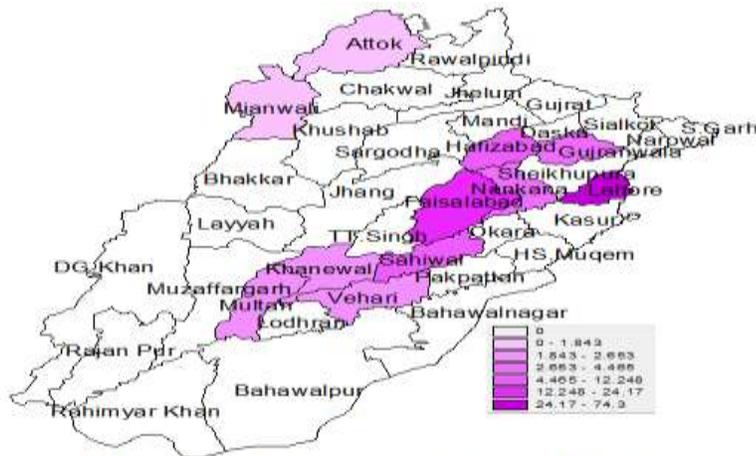
Figure 10 shows pattern and intensity of Dengue virus in the month of October. Just five cities holding 13% geographical area are Dengue free zone while remaining geographical patches are suffering from Dengue with fluctuating intensities. Hotspots cover 18% geographical area with Lahore, Sheikupura, Faisalabad, Okara, Pakistan, Jhelum and Rawalpindi. Here 28% geographical area is at a marginal level, 37% is at a high level. Lahore, Sheikupura, Rawalpindi, Faisalabad carries consistent intensity.



Geographical Pattern and Intensity of Dengue Virus among Females in November

Figure 11: Geographical Pattern and Intensity in November

Figure 11 show pattern and intensity of Dengue virus in the month of November. This thematic map reflects epidemiological situation is getting better. In this month temperature is lower down drastically which restrict Dengue activities. Now 50% geographical area is Dengue free zone. a marginal level intensity reflects through 28% geographical area 15% at a low level and 7% at higher level. Here are three hotspot areas like Lahore, Faisalabad, and Rawalpindi.



Geographical Pattern and Intensity of Dengue Virus among Females in December

Figure 12: Geographical Pattern and Intensity in December

Figure 12 shows pattern and intensity of Dengue virus in the month of December. In this month temperature is below 10°C and Dengue stop function. The epidemiological situation is better and under control as compared to

last thematic map. Now 71% the geographical area is Dengue free zone 5% marginal 18% low and just 6% is reflecting high-level intensity. There are only two hotspot areas like Lahore and Faisalabad. One thing is obvious that Lahore remains presents in all thematic maps and consistently as hotspot area.

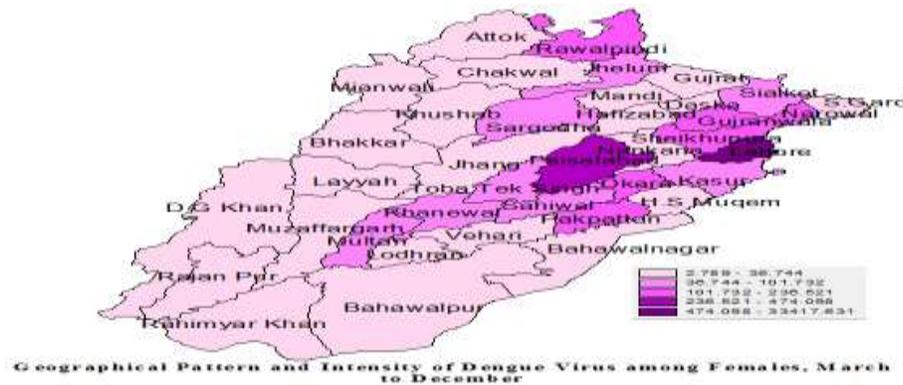


Figure 13: Geographical Pattern and Intensity March to December

Figure 13 shows pattern and intensity of Dengue virus, March to December. It is a summary of 37 epidemiological weeks of registered female patients. Outbreak covered 100% geographical area of Punjab no administrative zoon was Dengue free. In it, 27% geographical area remains at a marginal level, 33% at a low level, 26% high level, 14% highest level hotspots.

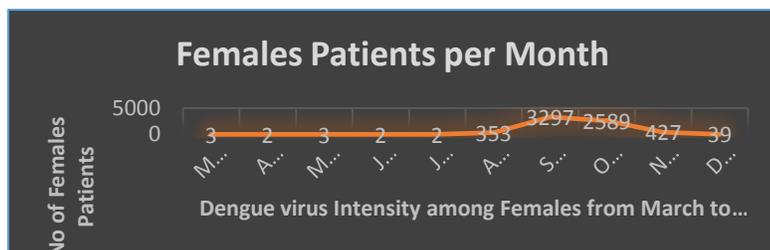


Figure 14: Dengue virus Intensity among Females from March to December

Figure 14 shows a number of female patients with respect to month wise. We can observe from March to July a just a couple of patients arriving per month. August get started along with a session of monsoon rain, provide a suitable environment of Dengue virus. August to November session show outbreak which increases the number of female patients. In December outbreak is to its terminal stage because Dengue stops working when the temperature is below ten centigrade.

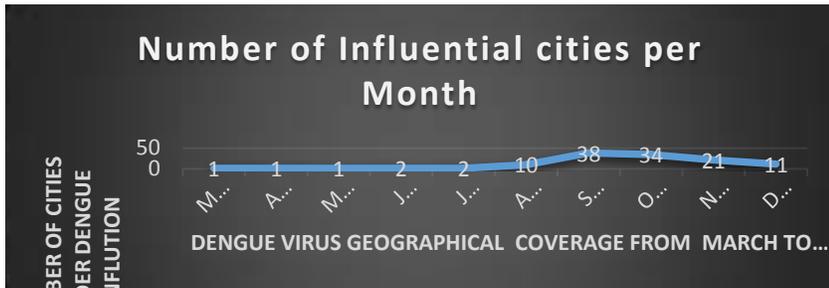


Figure 15: Dengue virus Geographical pattern among Females from March to December

Figure 15 shows a number of influential geographical regions with respect to months. Influential cities pattern is almost identical as compared to a number of Female patients with respect to months. March to July number of influential cities is not more than two like the previous graph. Influential cities increase rapidly as August get the start and up to November carry the same session. There are total 38 districts in Punjab region which all become influential in September.

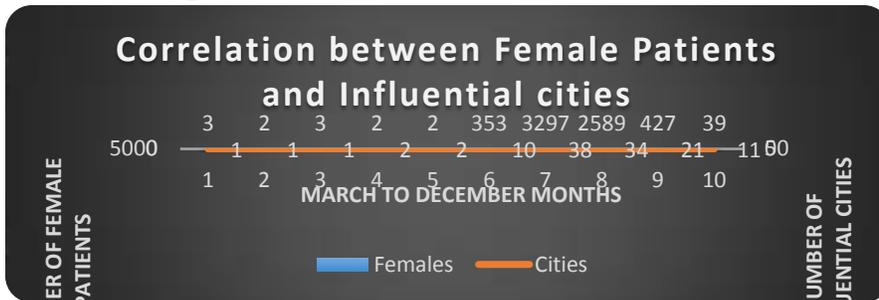


Figure 16: Correlation between Female Patients and Influential cities

Figure 16 shows a strong correlation of 0.93 between Female patient and Influential cities. It shows a seasonal pattern between Female patients and Influential cities which are from August to December, before and after this session no chances of an outbreak.

Result and Discussion

In this research studies, we come to know that seven thousand female’s patients were infected during this outbreak and 86% females were from capital city Lahore only. In the start from March to July virus restraint in Lahore or couple of cities because of temperature , humidity was not favorable to support Dengue activities. Dengue stops working when it is too hot like more than 45 centigrades or too cold like below 10 centigrades. A strong correlation of 0.93 was observed between registered patients and number of influential districts of Punjab. Outbreak get to start from Lahore city and move to the other cities of Punjab from time to time. The reason behind the flow of Dengue virus from Lahore to other city was Transportation of Patients from one place to another place. As the mosquito flight is limited to maximum up to 3km. It is observed that dengue outbreak follow a seasonal pattern start from August up to December. Most of the wreckage was done in the month of September and October. All districts were fully affected by Dengue virus in September. Lahore, Sheikhpura, Faisalabad, and Rawalpindi emerged as Hotspot areas of this outbreak. The average number of patient registered per week from August to November only at Lahore was 707.68 patients.

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