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Geospatial analysis of thalassemia patients' prevalence in district Gujrat, Pakistan in 2015-2016

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Abstract

Using Geographical Information System health analysis measures can contribute to the profound understanding of health related issues and disease occurrence for public awareness and forecasting essential improvements. The present research was designed to determine the cluster analysis of thalassemia patients in Gujrat district. A purposive sample comprised 142 thalassemia major survivors was gathered conveniently from the main and only center for thalassemia in Gujrat district Punjab, Pakistan. After marking spatial location of their home addresses in a point shape file the data were analyzed using geographic information system (GIS) technology and spatial analysis techniques. Kernel density function in ArcMap 10.3 enabled to identify clusters of thalassemia patients in Gujrat district. The patient data reveals that 95% of all cases were between 05-20 years of age. Based on incidence density and spatial maps, the results of the study revealed that the major cluster of thalassemia patients is located in tehsil Gujrat, Moreover, relatively fewer clusters of patients are found in Tehsil Kharian and Sara-i-Alamgir. Currently, only one thalassemia center i.e. Sundas Foundation is functioning in district Gujrat. The methodology and the results of this study may be beneficial in developing an integrated system to monitor, control and prevent this disease.

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Introduction

Disease mapping using ArcGIS for spatial distribution of disease to search for high risk areas is widely used in public and environmental health field. The presence of hereditary thalassemia disorder in Pakistan has been known for a long time but it is neglected always due to some social and cultural values or most of the people are unaware of this disease. Pakistan is a developing country having population of over 140 million people. 40% of the total population are younger than 15 years of age. CBR (crude birth rate) is 29 for every 1000 people and the infant mortality rate is 101 for every 1000 live births (Ahmad *et al.* 2002). There are no primary health care centers and the health system is based on hospitals. In Pakistan hemoglobinopathies are chief genetic disorders. Around 5% of population contains beta (β) thalassemia, and 0.5 to 1 % are carriers of hemoglobin S or hemoglobin E. Annually around 5250 infants are born with b thalassemia major. Consanguineous marriages, lack of awareness and low literacy rate are the major reasons of increased ratio of thalassemia patients in Pakistan (Baig *et al.* 2006).

Research on this disease is very less in Pakistan particularly in rural areas because of no national level policies. The areas of Pakistan which lies on river banks are totally unaware of these problems therefore, maximum numbers of children are having this problem. The actual magnitude of thalassemia patients is still unknown. Thalassemia lies mostly in northern areas of Pakistan due to the backwardness and low literacy rate. Demographically if we look the distribution of this disease, it lies maximum in Pathan group and then Punjabi group (Khattak and Saleem, 1992).

The thalassemia is a cluster of genetic disorders that avoid the body from making adequate quantity of high quality blood (Grow *et al.* 2014). Thalassemia is a group of genetic diseases of abnormal hemoglobin mixture where the normal hemoglobin protein is produced in minimum level than usual. This situation causes anemia of varying degree, which can lead to life threatening. It can be categorized according to the deficient globin chain which are alpha (α) or beta (β) thalassemia (Harteveld and Higgs, 2010). Patients with severe anemia who receive regular blood transfusions become iron burdened, which increases damaging free radical activity and lowers antioxidant levels in their bodies. Newborn screening and prenatal diagnosis are vital in controlling of patients. Existence of the patients chiefly depends on regular blood transfusions that may lead to further difficulties such as absorptive iron overload and transfusion transmitted infections (TTIs) (Weatherall, 2010). Thalassemia and sickle cell disorders are the commonest human inherited hemoglobin disorders that can be treated affectively, and also prevented at public level.

People of thalassemia minor have a 50/50 chance to pass the gene to their children, who would also be carrier of thalassemia minor, supposing that the other parents are not affected. Many of individuals are given iron replacement under the mistaken belief that their anemia is the iron-deficient type. Excess of iron can be injurious; it is important to reveal decisively that a patient has iron shortage before beginning treatment. If there is any query as to whether a patient has Thalassemia, it is sensible approach to consult a hematologist before beginning of any treatment.

The people of Gujrat are facing several economic, educational and above all health problems. There are a number of severe diseases observed among the people of Gujrat but beta thalassemia is more dangerous in all. It caused high rate of infant and child mortality in district Gujrat.

The present research aims to investigate this disease by cluster identification of thalassemia survivors in Gujrat district using ArcMap 10.3. Furthermore, the proposed study intends to review the location of current thalassemia and blood transfusion centers and to identify new locations where there is need to develop new thalassemia and blood transfusion centers.

In the present study our main concern is the investigation of beta thalassemia patients, which is a severe form of thalassemia. Beta thalassemia comes in two serious types, thalassemia major (or Cooley's anemia), and thalassemia intermedia. The mainstream of researches in the domain of beta thalassemia has been carried out by western researchers (Nikolaidia and Xanthidia, 2011; Weatherall, 2010; Jetawattana, 2005; Eleftheriou, 2003). Literature review reveals that many researchers have conducted researches on beta thalassemia purely medical based (Din *et al.* 2014; Rezaee *et al.* 2012; Weatherall, 2010; Khattak and Saleem, 1992) and only handful of researches have been conducted on beta thalassemia with the use of GIS technology. It is a common genetic severe disease mostly lies at tropics and the countries lies at tropics also known as thalassemia belt and beta thalassemia always remain the main reason of research in west and east (Eleftheriou, 2003).

In Pakistan research is conducted on the old traditional orthodox base thinking of people in the matter of marriage which is the major cause of spreading of beta (β) thalassemia. These researches proved that with the absence of basic awareness, provision of proper medical facilities at gross route level by the government and short and long term policies, thalassemia cannot be control completely. Society awareness and help is the basic step to get rid of it (Hafeez *et al.* 2007). The research on beta thalassemia in Pakistanis performed in purely medical perspective. (Hafeez *et al.*2007) investigated beta thalassemia mutations distribution ethnically, regionally and effect of consanguinity in patients mentioned for prenatal diagnosis.499 couples. 499 couples from approximately every cast of Pakistan were suggested to Genetic Lab, Lahore for prenatal detection of beta thalassemia. For type of mutation, cross sectional DNA analysis was done by Amplification Refractory Mutation System (ARMS) through which race, ethnicity and consanguineous relationship of couples was determined. Ratio of first cousin marriage is higher as compared to marriage out of relatives in Pakistan. From the data it was revealed first cousin marriage was 56.7% and 19.8% out of family. Beta thalassemia exists 60.7% in Punjabis and 25.5% in Saraikees, but mostly it lies maximum in Rajputs and then Jutt, Sheikh, Arain and Pathan, so through prenatal testing, it can be reduced affectively.

The geographical distribution of thalassemia patients using modern techniques such as GIS and Remote Sensing has not studied before therefore, the present study aim to analyze the spatial distribution of thalassemia patients with the help of ArcMap 10.3 software. Such kind of analyses will be helpful to identify spatial clusters of carriers of this disease. Later, in high cluster areas the genetic counseling, prenatal diagnosis and awareness campaigns can greatly reduce the rate of birth of affected infants and also improve the prognosis of potential patients. Geographic information systems (GIS) can be used to perform spatial analyses of regional data. The fast progression of GIS over past 20 years has helped the analysis of spatial processes and patterns (Moore and Carpenter, 1999). GIS has become a useful and efficient tool for decision making, health assessment, health evaluation and disease prevention planning (Karsentg and Leventhal, 2002; Nikolaidia and Xanthidis, 2011). Since approximately 80% of health and disease data have spatial properties, therefore, spatial analysis of public health and epidemiological studies in GIS environment have become widely used (Tao Hu *et al.* 2014; Gesler, 1986; Clarke *et al.* 1996). The results of the present study and the spatial map of patient distribution may be useful for the health planners and policy makers to take necessary steps for the prevention and control of this disease (Rytkönen, 2004; Richards *et al.* 1999). This investigation used ArcMap 10.3 to create a geo-database of Thalassemia b cases in hospitals of Gujrat in 2015-2016.The spatial distribution of the patients were analyzed using kernel density method to offer a scientific basis for the prevention and control of this disease.

This study is significant endeavor in promoting awareness about the severe problem (i.e. thalassemia)

of the Gujrat district. It will attract the high officials' attention that will further be helpful in providing medical facilities, presently this problem is increasing gradually and might be a more severe problem in the future besides the other diseases.

This study will be beneficial for the study area's people, doctors, health policy makers and affected families to observe the reality this highly spreading of this genetic disease. So, they will need to focus on the basic causal factors of this unstoppable spread in order to take the precautionary measures for controlling thalassemia.

The mapping of thalassemia survivor in Gujrat district will be helpful for further research on identifying the location for new thalassemia centers. The identification of thalassemia major patients will be helpful in screening out the thalassemia minor patients in order to save them from future trouble if they get married with another carrier. Through this study the spreading of patients can be shown on the map at one place which will very helpful in understanding and taking the actions against this neglected and unrecognized cases of thalassemia.

Materials and methods

Study Area

District Gujrat is located between the Jhelum and Chenab Rivers in the Punjab plains, from 32°34′ to 25°.67′ north latitude and 74°04′ to 74°.18′ east longitude. It is bounded by Jammu and Kashmir in the NE, River Jhelum in the NW and Sialkot and Gujranwala in the SW. River Chenab is situated on the east and SE side, and Mandi Bahauddin district lies on the western side (Fig. 1).

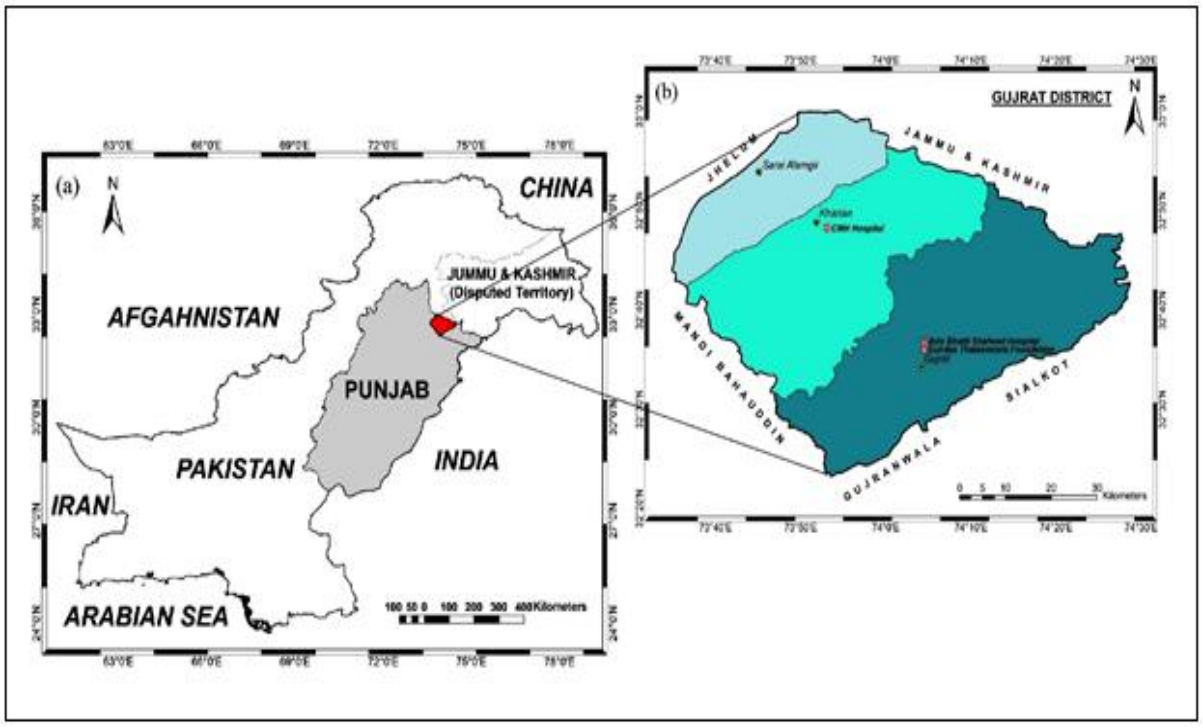


Fig. 1. Map showing location of (a) study area in red colour, (b) main tehsils (Gujrat, Kharian and Sarai Alamgir), public hospitals and source of data collection (Sundas Foundation).

Gujrat is connected by metaled road with major cities of the Punjab e.g. Gujranwala (62 Km), Sialkot (63Km), Lahore (134 Km) and Sargodha (195 Km). It spread over an area of 3,210.76 km2, and it has three Tehsils, Gujrat, Kharian, and Sarai Alamgir. 5.9% (188.09 km2) of the total area is buildup and approximately 76.01% of the total area is cropland (Fig. 3). Total Population of the city was 342,285 in 1998 (Urban Unit, 2015). From 1981 to 1998 literacy rate was 72.2%, average household size was 7 and population growth rate was 2% (GOP, 1998). The area has good fertile land with dark brown clay (Fig. 3).

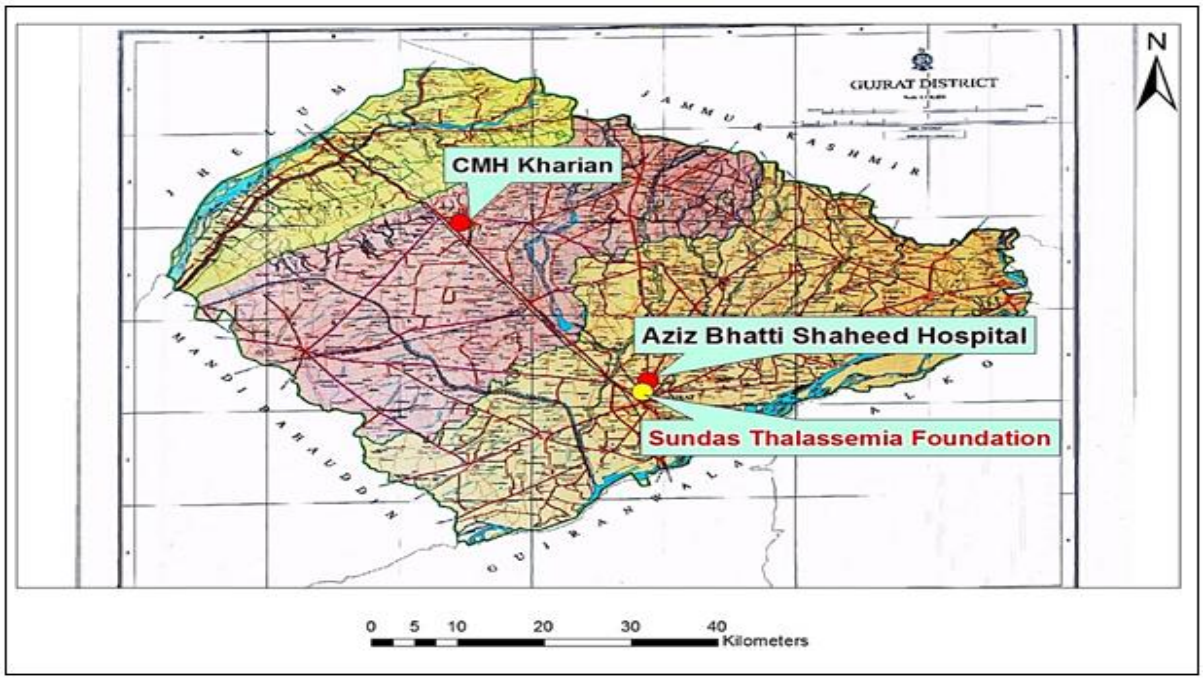
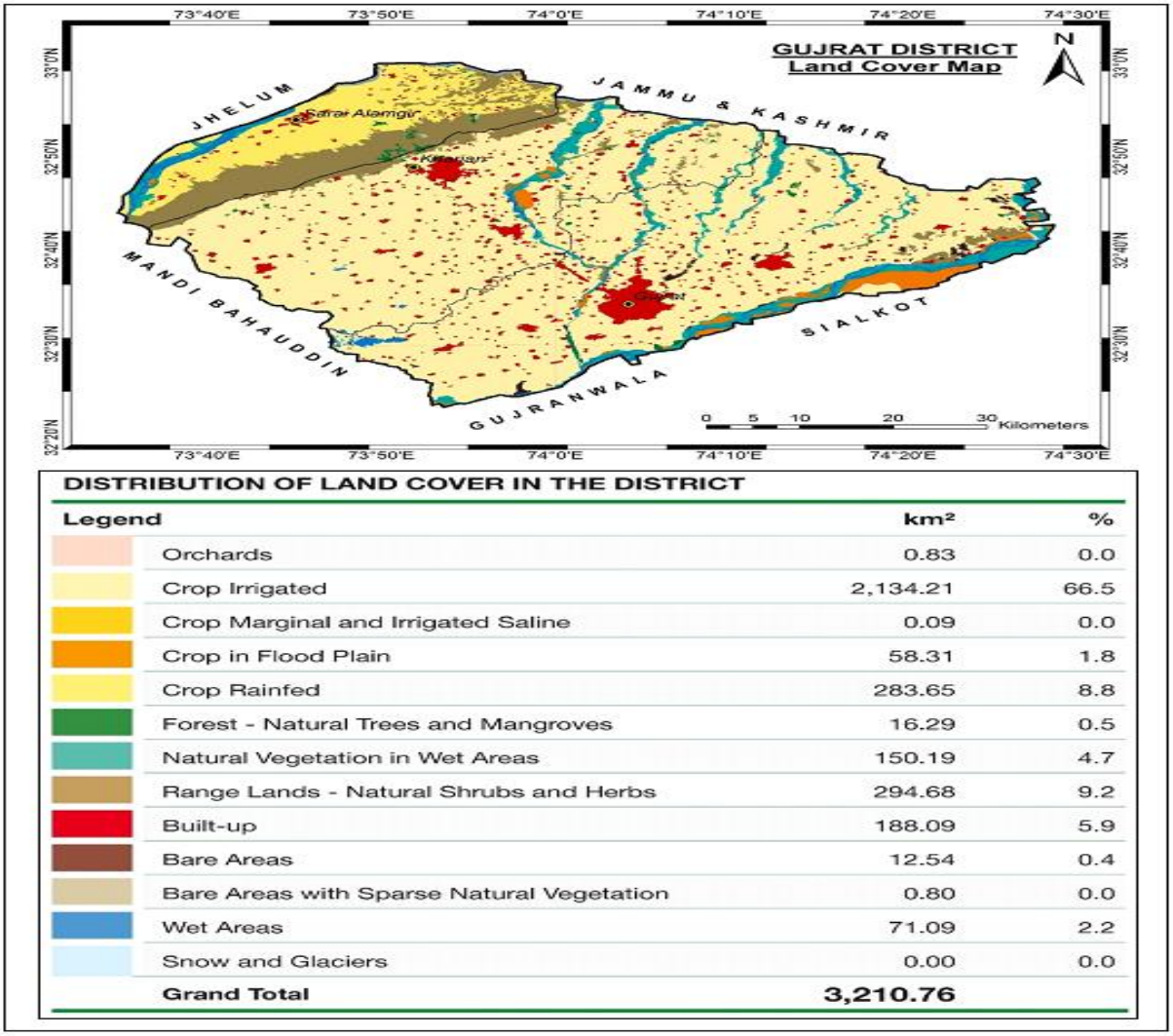


Fig. 2. Map showing location of hospitals.



DISTRIBUTION OF LAND COVER IN THE DISTRICT

Legend	km²	%
Orchards	0.83	0.0
Crop Irrigated	2,134.21	66.5
Crop Marginal and Irrigated Saline	0.09	0.0
Crop in Flood Plain	58.31	1.8
Crop Rainfed	283.65	8.8
Forest - Natural Trees and Mangroves	16.29	0.5
Natural Vegetation in Wet Areas	150.19	4.7
Range Lands - Natural Shrubs and Herbs	294.68	9.2
Built-up	188.09	5.9
Bare Areas	12.54	0.4
Bare Areas with Sparse Natural Vegetation	0.80	0.0
Wet Areas	71.09	2.2
Snow and Glaciers	0.00	0.0
Grand Total	**3,210.76**	

Fig. 3. Land cover map of district Gujrat, adapted from FAO (2014).

The climate of the city is extreme hot in summer and cold in winter.

Data acquisition

A purposive sample comprised 142 thalassemia survivors was gathered conveniently from the main and only center for thalassemia (Sundas Foundation) in Gujrat district Punjab, Pakistan. Home addresses data were obtained from the medical records of hospital patients with beta thalassemia in Gujrat, 2015, including Aziz Bhatti Shaheed hospital (Govt. Hospital), Sundas Foundation and CMH (Combined Military Hospitals) Kharian. The spatial location (coordinates) of thalassemia patient's houses were collected by using GPS (global positioning system).

The most recent information about the disease was collected from the doctors and patients. Various books in soft and hard form, reports from different NGOs and research papers were productive in giving the most recent and authentic information. Different websites were also consulted related to the research work. The data indicate that most of the patients are from tehsil Gujrat (104), following tehsil Kharian (34) and Sarai Alamgir (04) (Fig. 5).

Data tabulation

The primary data were tabulated in Microsoft Excel datashe*et al*ong with GPS locational points attached to the home address of the patient prior to analysis in GIS. Later, the patient's locational data file was added in the ArcMap 10.3 software in the form of point shape file for further analysis (Fig. 5).

Data analysis

The data were analyzed by applying incidence density analysis. Incidence density analysis is one of the basic and significant methods of epidemiologic investigation. Kernel density function in ArcMap 10.3 were used to identify clusters of thalassemia patients in Gujrat district. This function computes a magnitude per unit area from using a kernel function to fit a smoothly tapered surface to each point.

Results and discussion

Trend of marriage

Thalassemia is a genetic disorder of hemoglobin, which cause due to consanguineous marriage. The data collected from the patients and interviews from the effected families indicate that the ratio of consanguineous marriage is 85% and out of family marriage is 15%. It clearly indicates that the high rate of beta thalassemia major in patients is the result of traditional marriage system within the cast (Fig. 4).

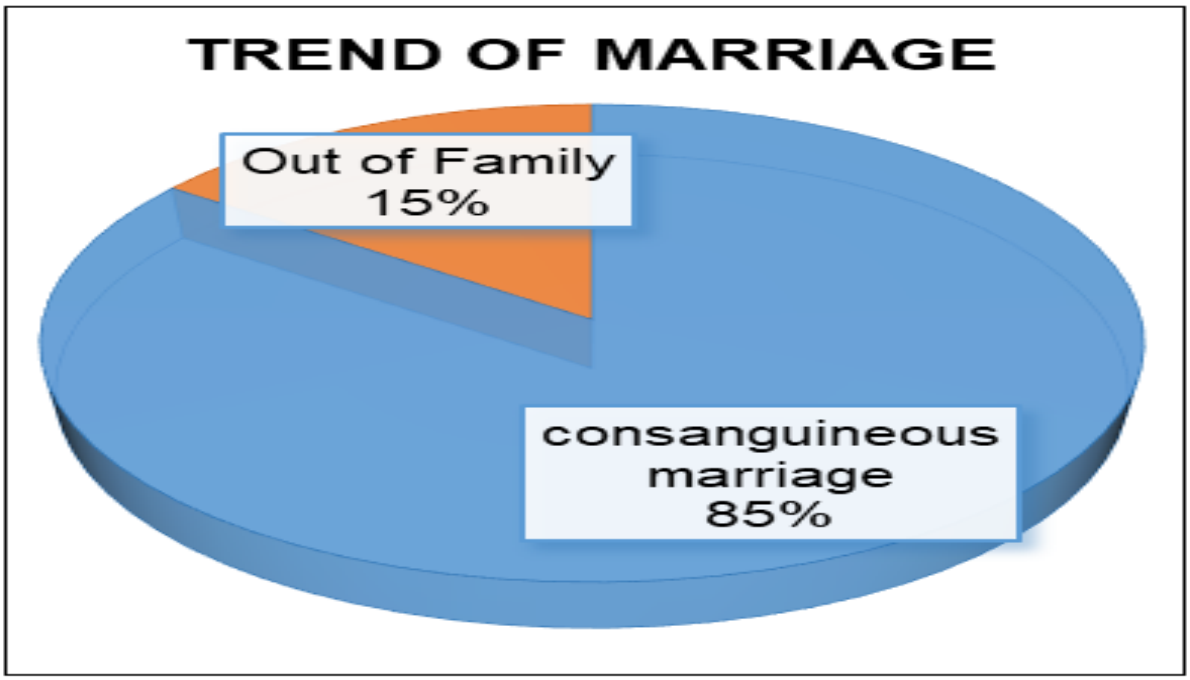


Fig. 4. Source: Sundas Foundation Gujrat.

Patients 'age structure

Thalassemia appears within one year of a child birth and remain along with it throughout patient's life. Low literacy rate in villages cause lack of health awareness and Gujrat mainly comprised rural area (Fig. 5). Outcome have shown that 60% of beta thalassemia major patients lies within the age group of 5-10 years, 20% patients fall within the age of 10-15 years, 15% patients are within the age of 15-20 years and only 5% patients are above the age of 20 years, which are very rare cases (Fig. 6).

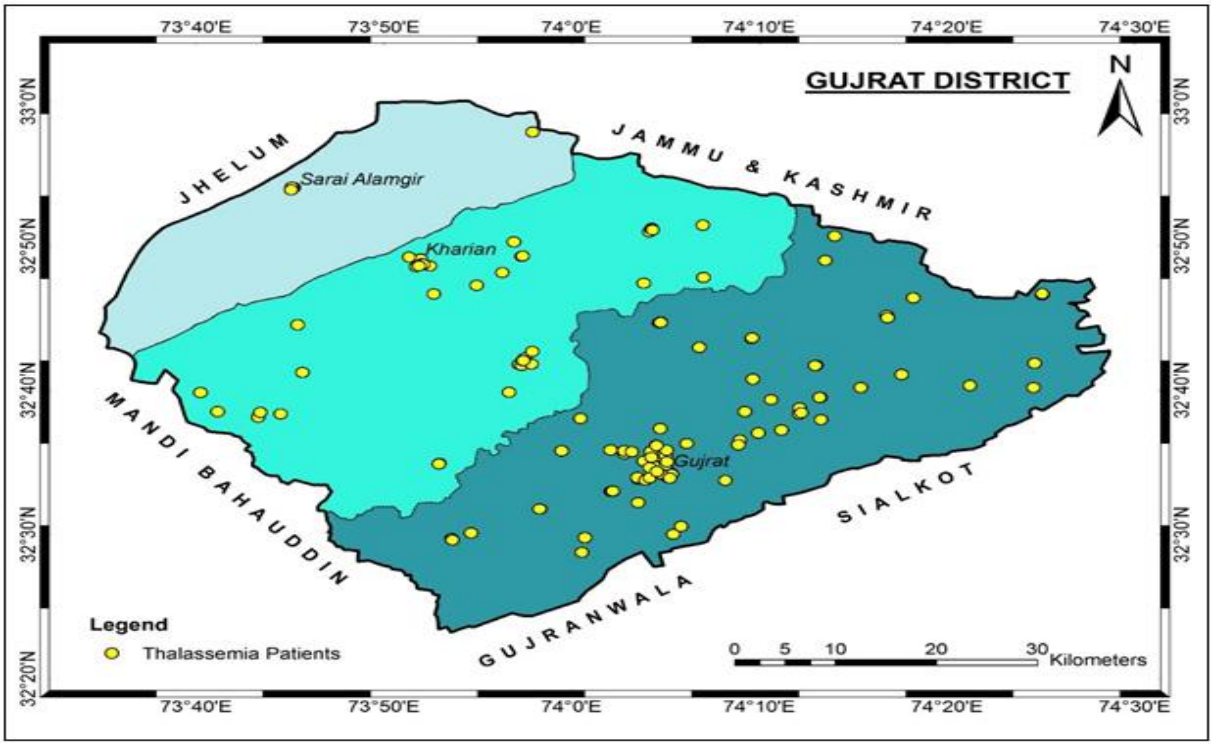


Fig. 5. Map showing spatial location and distribution of 142 beta thalassemia patients in district Gujrat.

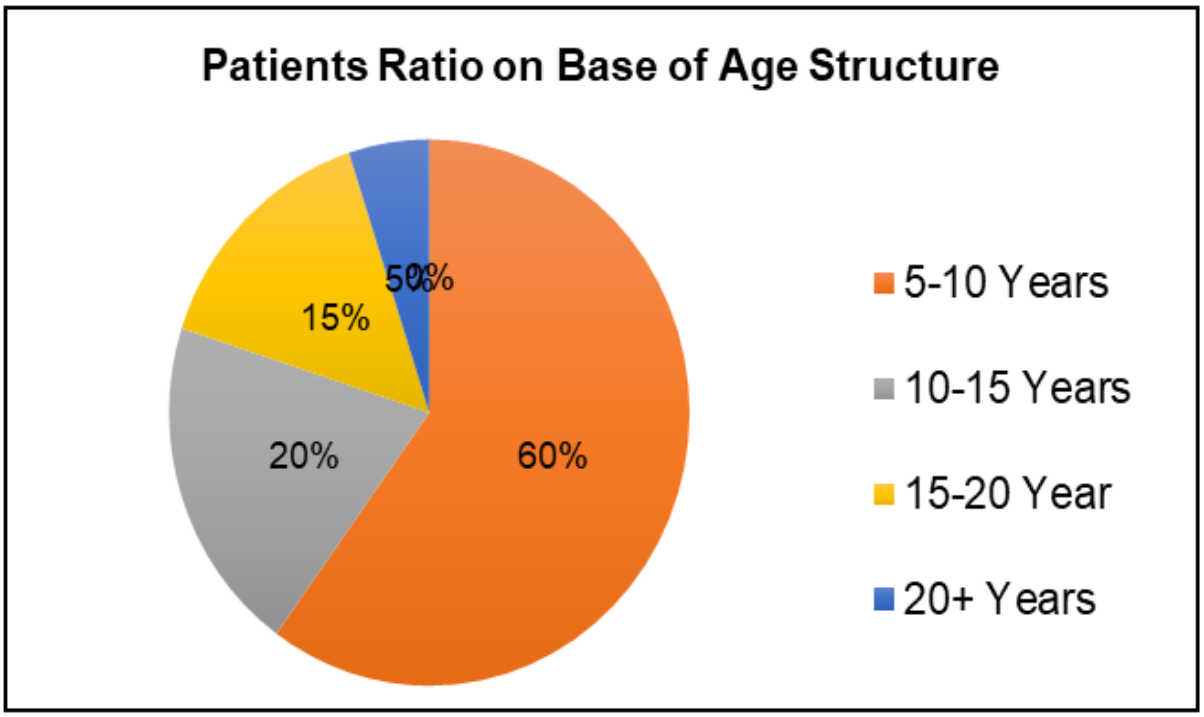


Fig. 6. Source: Sundas Foundation Gujrat.

The life expectancy of Thalassemia patient is below 13 to 15 years approximately because of unavailability of fully equipped hospital for proper purification of blood, shortage of blood donor, inadequate medicines, supplies and injections because they are very expensive and cannot be afford by a normal person. By providing necessary awareness, and good health facilities at government level the life expectancy of such patients can be increased.

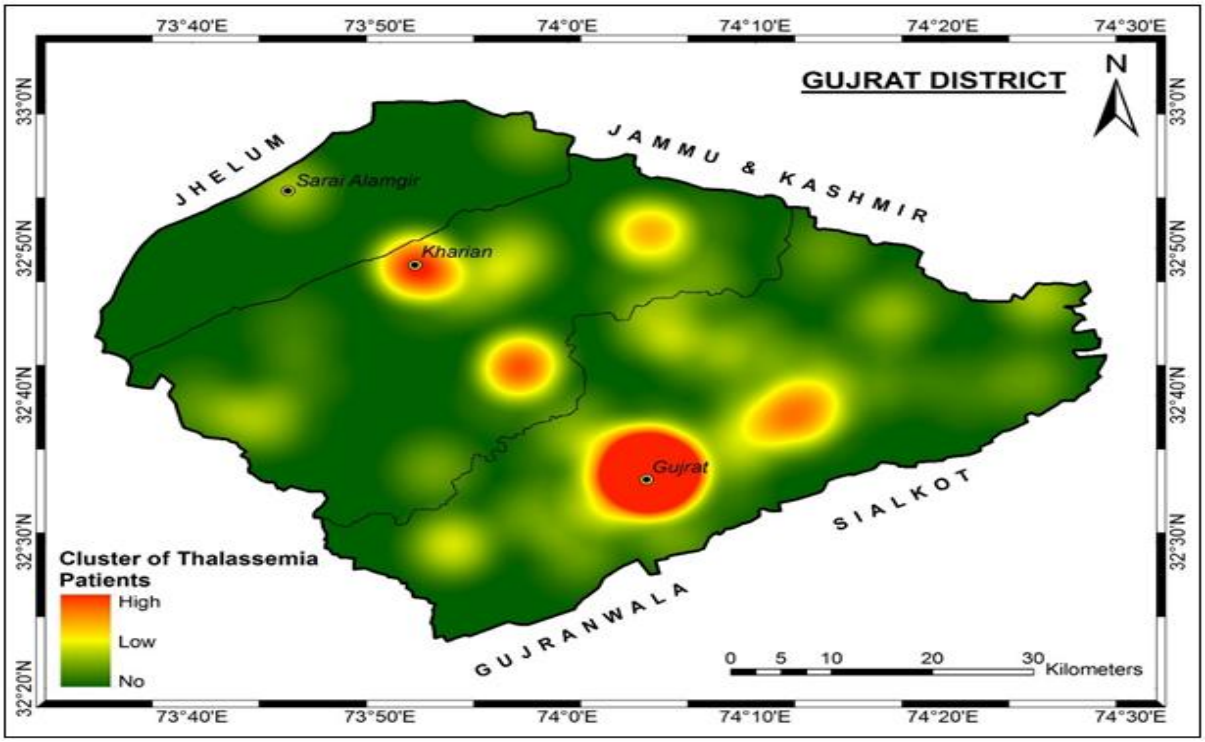


Fig. 7. Map showing spatial clusters of beta thalassemia patients in district Gujrat. Red color is showing high cluster value, yellow is low and green represents no value.

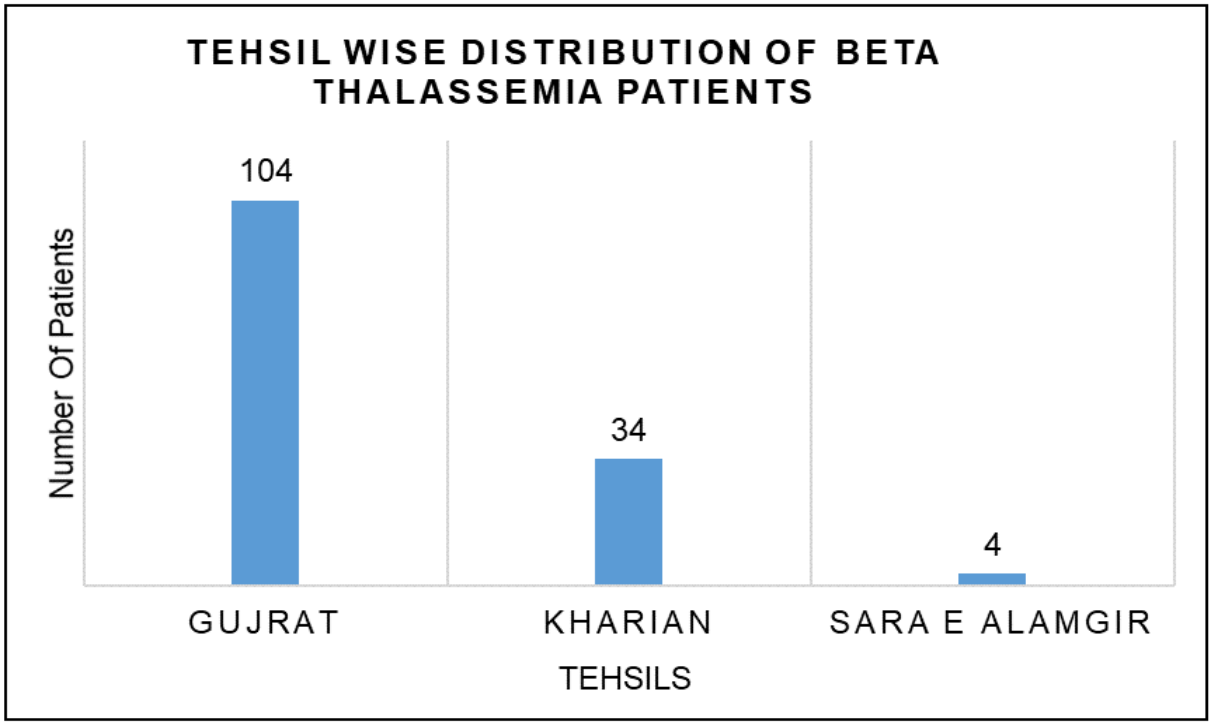


Fig. 8. Graph showing total number of beta thalassemia patients in tehsils of district Gujrat.

In developed countries where the facilities are very high and effective, thalassemia patients have the chance of living above 40 years of age. Like in Cyprus, 83% thalassemia patients have finished higher education, on the other hand, 25% have passed from university.22% of patients are spending marital life, 73% of them have three to four kids. 79% of patients in Cyprus are putting their efforts in agriculture and handicrafts and as teachers, nurses and medical staff (Eleftheriou, 2003).

Cluster analysis

After performing the analysis, results have shown that there are a lot of patients in the district who are suffering from this severe and miserable disease. Most of the population of Gujrat district lives in rural areas and especially on the backward areas along the riversides. The people are unaware of this disease while they have strong system of consanguineous marriages. The density analysis reveals that the major cluster of patients is in tehsil Gujrat and then in Kharian. Some scattered clusters can also be observed in the district. The high density cluster in tehsil Gujrat can be due to the availability of one and only blood transfusion center (Sundas Foundation). Effected people prefer to migrate in the city for easy access and timely treatment. After mapping clusters of patients (Fig. 7 and Fig. 8) and location of hospitals (Fig. 2) it seems that hospitals are at appropriate location. However, considering the high number of patients it is recommended that the main hospitals may be upgraded through the disease related trained medical staff, blood screening machines, and modern purification methods. Furthermore, availability of necessary treatment budget and government level policies will facilitate the patients.

Conclusion

The present study revealed the significant ability of GIS in order to elucidate the geographic distribution of thalassemia survivors. Results of the study revealed that the high percentage of consanguineous marriage is the major cause of beta thalassemia major. The outcome cluster analysis have shown the high prevalence of thalassemia major in tehsil Gujrat then in tehsil Kharian and Sarai Alamgir Tehsil. The huge distance of tehsil Sarai Alamgir from tehsil Gujrat may be the cause of less registration of thalassemia patients in tehsil Gujrat hospitals and they may prefer to travel toward district Jhelum thalassemia centers, which are comparatively more near to them. Outcome have shown that 60% of thalassemia major patients lies within the age of 10 year, 20% patients fall within the age of 10-15 year, 15% patients are within the age of 15-20 year and only 5% patients are above the age of 20 year which are very rare cases. But in the developed countries where the facilities are very high, thalassemia patients have the age ratio above 40 year. This study is significant endeavor in promoting awareness about the severe beta thalassemia genetic disorder. The methodology for mapping of thalassemia survivor in Gujrat district will be helpful for further research on larger areas to investigate spatial distribution of such patients and to establish new thalassemia centers at or near high cluster area. Through this study the spreading of patients can be shown on the map which will be very helpful in understanding and taking necessary actions for neglected and unrecognized cases of thalassemia.

Recommendation

In the study area upon which this research is conducted, there is vast need of awareness on the grass root level because people are strongly tied in the concept of consanguineous marriage in the region. Besides this there is also need of local level budget specifically for thalassemia patients because the medication of these patients is very expensive as compared to other diseases. The new hospital or thalassemia centers might also be constructed in other regions so that patients can get benefits and treatment at their door step. Availability of skilled doctors and staff should be there for the better treatment of thalassemia patients. Medicines and injections are not available at local level because they are imported from the other countries. There supply at local level may be made possible at affordable prices. Finally, the concept of hemoglobin electrophoresis test may spread among the public not only in study area but also at national level. It is a

kind of precautionary measure to control the speedy spread of thalassemia.

References

Ahmad M, Mahmood A. 2013. Three Years Rolling Plan. District Gujrat. Retrieved from www.phsrp.punjab.gov.pk/downloads/3yrp/gujrat.docx.

Ahmad S, Saleem M, Modell B, Petrou M. 2002. Screening extended families for Genetic hemoglobin disorders in Pakistan. The New England Journal of Medicine **347(15),** 1162–1168. http://dx.doi.org/10.1056/NEJMsa013234.

Baig SM, Azhar A, Hassan H, Baig JM, Kiyani A, Hameed U, Rabbi F, Bokhario H, Aslam M, Ud Din MA, Baig SA, Hassan K, Qureshi JA, Zaman T. 2006. Spectrum of beta-thalassemia mutations in various regions of Punjab and Islamabad, Pakistan: establishment of prenatal diagnosis. Haematologica, 13-15.

Clarke KC, McLafferty SL, Tempalski BJ. 1996. On epidemiology and geographic information systems: A review and discussion of future directions. Emerging Infectious Diseases **2(2),** 85-92.

Din GU, Malik S, Ali I, Ahmed S, Dasti JI. 2014. Prevalence of hepatitis C virus infection among thalassemia patients: a perspective from a multi-ethnic population of Pakistan. Asian Pacific Journal of Tropical Medicine **7(1),** S127-S133. http://dx.doi.org/10.1016/S1995-7645(14)60218-2.

Eleftheriou A. 2003. About Thalassemia. Nicosia: Thalassemia International Federation.

Food and Agriculture Organization. 2014. United Nations land cover atlas of Pakistan - The Punjab Province. Retrieved from Web: http://www.glcn.org/downs/prj/pak/pak_atlas_LCpunjab_2014.pdf.

Gesler W. 1986. The uses of spatial analysis in medical geography: a review. Social Science and Medicine **23,** 963-973.

Government of Pakistan. 1998. District census report of District Gujrat: Population Census Organization, Statistics Division.

Grow K, Vashist M, Abrol P, Sharma S, Yadav R. 2014. Beta thalassemia in India: current status and the challenges ahead. International Journal of Pharmacy and Pharmaceutical Science **6,** 28-33.

Hafeez M, Aslam M, Ali A, Rashid Y, Jafri H. 2007. Regional and ethnic distribution of beta thalassemia mutations and effect of consanguinity in patients referred for prenatal diagnosis. Journal of the College of Physicians and Surgeons–Pakistan. **17(3),** 144-147. http://dx.doi.org/03.2007/JCPSP.144147.

Harteveld CL, Higgs DR. 2010. α-thalassemia. Orphanet Journal of Rare Diseases 1-21. http://dx.doi.org/10.1186/1750-1172-5-13.

Jetawattana S. 2005. Thalassemias, disorders of hemoglobin. Free Radicals in Biology and Medicine **77**, 1-23.

Karsentg E, Leventhal A. 2002. Health geographic information systems (HGIS)-A tool for health planning and epidemiology. Harefuah **141,** 1070-1075.

Khattak MF, Saleem M. 1992. Prevalence of heterozygous b-thalassemia in northern areas of pakistan. Journal of Pakistan Medical Association. **43,** 42-44.

Leventhal B. 2002. Geodemographics in Robin J. Birn (ed.). The International Handbook of Market Research Techniques, 2nd edn. London: Kogan Page, p 103-25.

Moore DA, Carpenter TE. 1999. Spatial analytical methods and geographic information systems: Use in

health research and epidemiology. Epidemiologic Reviews **21,** 143-161.

Nikolaidia P, Xanthidis D. 2011. The distribution of medical facilities available for chronic disease patients through GIS visualization Case study: Central Macedonia, Northern Greece. Latest Advances in Information Science and Applications. 177-183.

Rezaee AR, Banoei MM, Khalili E, Houshmand M. 2012. Beta-thalassemia in Iran: new insight into the role of genetic admixture and migration. The Scientific World Journal 635183. http://dx.doi.org/10.1100/2012/635183.

Richards TB, Croner CM, Rushton G, Brown CK,Fowler L. 1999. Geographic information systems and public health: Mapping the future. Public Health Reports **114,** 359-373.

Rytkönen MJ. 2004. Not all maps are equal: GIS and spatial analysis in epidemiology. International Journal of Circumpolar Health **63(1),** 9-24.

Tao H, Qingyun D, Fu R, Shi L, Denan L, Jiajia L, Yan C. 2014. Spatial Analysis of the Home Addresses of Hospital Patients with Hepatitis B Infection or Hepatoma in Shenzhen, China from 2010 to 2012. International Journal of Environmental Research and Public Health **11,** 3143-3155. http://dx.doi.org/10.3390/ijerph110303143.

Unit U. 2015. Gujrat city profile. Punjab cities improvement investment program. Retrieved from http://www.urbanunit.gov.pk/PublicationDocs/Punab%20city%20profiles/Gujrat%20City%20Profile.pdfon07.10.2015.

Weatherall DJ. 2010. The inherited diseases of hemoglobin are an emerging global health burden. Blood. **115**, 4331-4336. http://dx.doi.org/10.1182/blood-2010-01-251348.