INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 19, No. 3, p. 23-35, 2021
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

# Geo-spatial analysis and modelling of water borne diseases in District Multan

**Hameed Ullah[1], Rana Waqar Aslam[*2], Sajid Rashid Ahmad[1], Muhammad Ameer Nawaz Akram[2], Muhammad Burhan Khalid[3], Kanwal Javid[4], Aqsa Aziz[5], Danish Raza[2]**

[1]*College of Earth and Environmental Sciences, University of the Punjab, Lahore, Pakistan*

[2]*State Key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing (LIESMARS), Wuhan University, Wuhan, China*

[3]*Punjab University College of Information & Technology, University of the Punjab, Lahore, Pakistan*

[4]*Department of Geography, Government College University, Lahore, Pakistan*

[5]*Department of Geography, University of the Punjab, Lahore, Pakistan*

Article published on September 26, 2021

**Key words:** GIS, TDS, Water Quality, Disease, Diarrhea, Regression, Water borne disease

## Abstract

Pakistan offers the nation's citizens basic health care with a well-developed primary and public health system but the health sector is underdeveloped in the Southern areas of Punjab and Multan district is prominent area. Multan District has developed and evolved over time, but it still struggles to provide basic health services to its people, especially in rural areas. In rural areas, small health units are springing up, but they are under-equipped, and the workforce is under-trained and uneducated. In the Multan district, a total of 82 BHUs were chosen for this report. Five of the most common diseases in the study region have been identified and affect the population at an alarming rate. In the district of Multan, these five diseases are distributed unequally and affect people in different proportions and result in an annual death rate of 1000 people. In addition, the overall analysis of registered patients into BHUs is geographically represented. People who are diagnosed with different diseases on a yearly basis are often represented using graded colour scheme maps. Water samples were collected from various locations in order to link water-borne diseases to drinking water, as contaminated water is one of the leading causes of these diseases. The study's results showed that areas with low water quality (contaminated water) have a high number of patients (water-borne diseases), proving the study's validity. In rural areas with limited access to basic services and a lack of basic quality-of-life initiatives, a study was conducted to identify water-borne diseases.

***Corresponding Author:** Rana Waqar Aslam ✉ ranawaqaraslam@whu.edu.cn

**Introduction**

Punjab is a developed and institutionalized province with technology and health management skills. Punjab has over 3000 health-care centres that provide people with subsidized medical services. The focus of this research was on health issues in the Multan district, both public and private. Multan city has a large number of public and private health care facilities in contrast to other parts of the district. This study is focused on the public and private health problems of the district of Multan. In Multan city, in comparison with other districts, there are many public and private health centres open to the public. In rural areas small health facilities are built but not well equipped and employees are not well educated. In addition, health centres are not run adequately in rural areas and the place is not ideal for the citizens because they do not consider the population of the area they serve. For the other residents in those health sectors, the right place provides convenient access. A comparative two-sided analysis of the national survey in British and Wales is provided with paper GIS. The survey was carried out at several times 1991 and 2001 (Darren, 2003). Nevertheless, some communes with enormous funds to implement GIS have reported that they have scarcely been used. (Kohsaka, 2000). A GIS database occurrence containing additional details on situations in these locations based on where and what a digital map operates within the geographical area (Jonathan D. Sugimoto, 2007). During the 1990s, the use of GIS in local governments increased seven national surveys in 1997 (Thomas, 1999). The relationship between health and housing wealth was strongly positive. (Redpath, 1996). Electronic health records Community information system (CIS) links (EHR) systems are highly promising to address social health determinants inequalities (SDH) (Albert, 1992). Planning of the settlement in the Tower Hamlets health district of East London as part of the domestic and international trend towards primary health care development at local level (Curtis, 1989).

It can lead to better health by using the restricted concept of evitable mortality (McKee, 2003). In the current reconstruction process, the importance of healthcare networks and networks for popular health practices (Christopher, 2006). This article aims to improve the provision of new healthcare and social services organisations, which will lead to the establishment of new healthcare centres (Fleuret, 2011; Short, 2002). Geographers have rapidly changed and broadened their concerns about health inequalities in less than a decade (Cressie, 1996; Tahir, 2020). The holy grass of each company is to be well; life is to be "healthy" (Croxton, 1968; David, 2012; Amjad, 2019). But both trends are (surely) linked to a sustained divide in health and enlargement (Aslam, 2017; Easterlow, 2005).

The NHS reform led to the separation of the buyer's and DSS functions and has an important influence over their goals and practises. The NHS reform is now being implemented. (Dietrich, 1991; Curtis, 1989; Gould, 1992). Geography is an important element in all aspects of provision of health services. (Habib, 2020; Rashid. 2020), and the use of space interaction modelling. To generate residential-based service request performance indicators. (Gould, 1992; Andrews, 2004; Fazlay, 2003). One of the main objectives for healthcare planning is to ensure a fair geographical distribution of medical resources (Qingming, 2008). This study aims to evaluate the spatial distribution of health centres in Khartoum. This study analyses "the nearest neighbour analysis" Statistical inference tool data application (NNA) (Ahmed, 2014; Ahmed, 2013; Abdurrahman, 2013).

The use of geography information systems in the FIG. method of health management in Kaduna and Nigeria Chikun Local government regions (Abbas, 2012; Maantay, 2002; Sonam, 2015). The range of GIS-technologies including malaria, leukaemia. geographic information systems. Two research fields of "classically" planned infectious disease and schistosomiasis used cancer tuberculosis and applications (Tanser, 2006; Hirschfield, 1995; Luo, 2004). There is spatial variation in the disease's racial and ethnic patterns, as factors such as climat, altitude or environmental toxins are affected (Waters, 2008;

Burgert, 2014; Michael, 2011). The burden of an increased demand for health care as a result of the projected spreading result may be high in many vulnerable and marginalised populations 14 and coverage of reforms (Devon, 2015; Ocasio, 2007; Dennis, 1982; Dennis, 1984). In consequence, a geographic area as small as possible must be used for the calculation of the population of the basin (Skidmore, 1981; Fran, 2012).

The importance of the study was to establish the magnitude, negative effects and causes of waterborne diseases and to provide sustainable management strategies through geospatial techniques. Local authorities and the government neglect remote rural regions and people have not been receiving basic health facilities in the district for many years. Every union council of Multan district has basic health units, but installations and upgrades are never completed. Taking into account the importance of basic health facilities for district residents, the GIS is an effective tool to recognize areas that are overlooked and highlight areas that are vulnerable to diseases. In addition, the field of research could be explored and future research prepared to build on the findings of this study and refined its results by concentrating on reliable results of the association of diseases with water and location data. Individuals must be aware of the waterborne diseases results. This study analyses the location and spatial trends of water-borne diseases and how these diseases impact the residents of the Multan District.

## Material and methods

Different tools and techniques were used to determine the catchment area of Healthcare facilities in Multan district, such as (GIS, Remote Sensing, and Cartographic), which helped to create temporal maps and images for performing analysis on the collected data from the field survey.

*Investigation site*

Multan is a city in Punjab that is 227 square kilometres in size (88 sq mi). Dera Ghazi Khan and Bahawalpur are the closest major cities. Multan is situated in a gorge formed by five central Pakistani rivers. The Sutlej River is located between Bahawalpur and Muzaffar Garh, which is separated by the Chenab River. The town is surrounded by a flat and alluvial plain, used in mango and citrus farming. The hottest temperatures in Pakistan are notorious for Multan. The highest temperature recorded was 52 degrees Celsius (126 degrees Fahrenheit), and the lowest temperature was 1 degrees Celsius (30 degrees Fahrenheit).

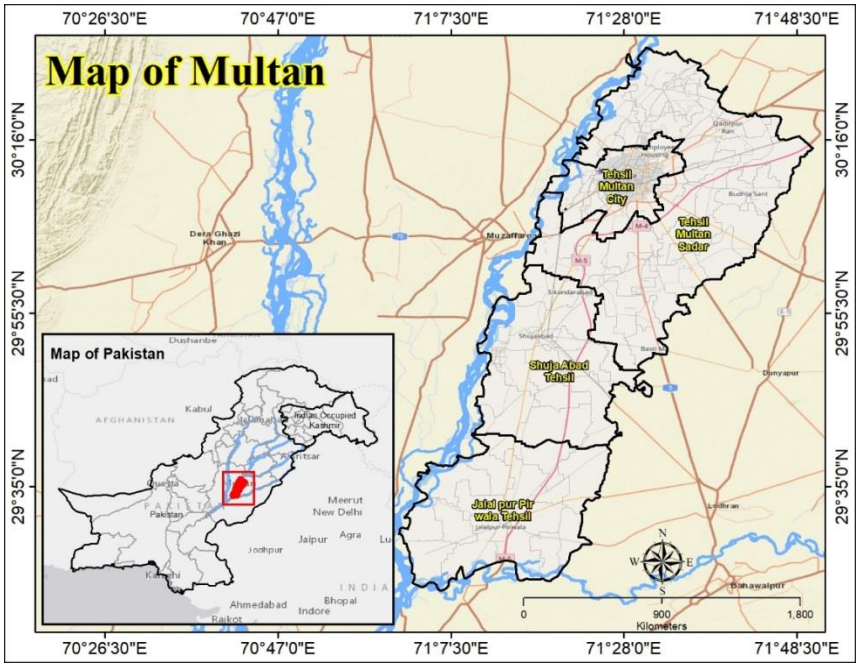


**Fig. 1.** Study area Multan.

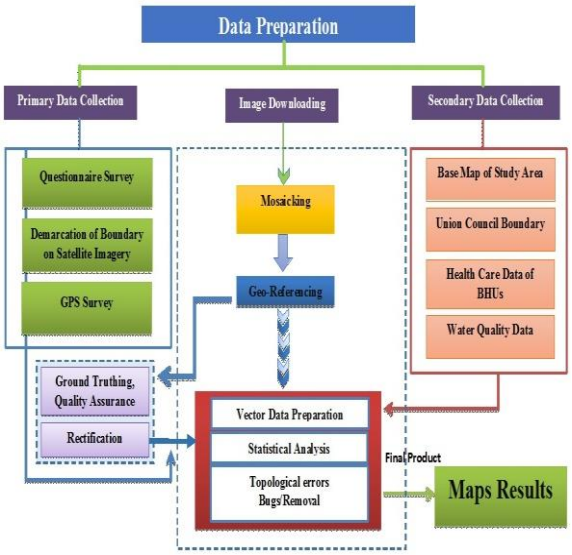


**Fig. 2.** Flow chart.

*Primary data.*

*Surveys.* This method is very useful for collecting primary data, particularly for the study area survey with its location. A land field survey was performed for this purpose, consisting of three separate types of surveys.

- Field survey in Multan to determine the position of health problems.
- A survey of BHUs in Union Councils based on a questionnaire.
- A GPS surveys

The field survey is a vital part of the observation of the region because it highlights problems and gathers firsthand knowledge. When collecting samples, there are certain prerequisites that must be met. The research area was District Multan, and the field survey was conducted there.

*GPS survey in the Multan District*

The process to obtain GPS data was described briefly. For any object on the earth's surface, the Global Positioning System (GPS) provides precise and relative position information. In order to correct the Google earth picture, points on Multan district boundaries and 82 BHU points in Multan district were collected for this analysis. By assigning these coordinates to these locations, they also assisted in the location of every object on the digital map. GPS was also useful for gathering some unique data in the study field, such as the position of BHUs in Union councils.

*Digitized maps of downloaded image*

After the image uploading and geo referencing process of Multan District was completed, the digitalisation process was completed. For digitization, Arc GIS 10.5 is used. This programme is specifically designed to create maps from photographs that have been digitised, as well as to perform a variety of analyses. In this study, roads in the Multan study area were digitised, and a variety of features were displayed on various maps.

*Questionnaire survey*

A survey of the health services provided by government healthcare services was conducted in different union councils in the district of Multan to determine people's perceptions about satisfaction. The majority of people are dissatisfied with government healthcare facilities, but they have expressed satisfaction with senior doctors in hospitals. The upper class prefers private healthcare centres because they believe they have better treatment and checkups. Private healthcare is out of reach for the middle and lower classes, but the large number of people attending government hospitals exacerbates the situation.

*Health care centres infrastructure survey*

The filed survey regarding the quality of building facilities and technical equipments was conducted to assess the hospital infrastructural problems in Multan district. The majority of the hospital buildings are old, according to personal questions and interviews with residents, physicians, and government officials about the issues they face in the hospitals. Some of them are still using outdated technologies and are not using any digital or cutting-edge technology.

*Secondary data*

*Base maps*

Local governments are responsible for developing base maps of the regions. The base maps contain useful information on their respective areas. In Pakistan,

however, most basic maps are not in digital form, and hardcopy maps are in poor shape. The bulk of them are obsolete. These maps are unable to provide the necessary details since several factors were overlooked when they were developed. As a result, obtaining information from government departments' foundation maps is a challenging challenge. Base maps are created for this analysis in order to collect and extract information from current maps.

*Supporting base layers*

In the base maps that I have created in the database as a vector, it is also important to complete the maps with supporting layers. All of these layers were generated by digitising the acquired Google Earth image. Some notable landmarks have also been digitised to help locate the nearest spot.

*Union council boundary*

The local government provides the union council boundary, which is digitised by the Urban Unit of the Punjab Government's Planning and Development Department in Lahore.

The borders of the union councils have been revised and readjusted in accordance with the world coordinate system (standard system for projection). Health care location data was placed for further review after entering this union council's boundary to our district administrative boundary.

*Healthcare centres layers*

In this study, the healthcare (hospital) layers play a critical role. Public and private healthcare centres are the two main categories of healthcare facilities. Government agencies operate public healthcare centres, while private healthcare centres are run by private NGOs and doctors' staff on a limited scale.

These layers indicate the locations of hospitals in the communities they represent, as well as their catchment areas. It would be helpful to display the location and their covering zones using network analysis and buffer analysis, as well as to define potential planning areas.

*Total dissolved solids (TDS)*

Tiny quantities of organic matter dissolved in water are contained in total dissolved solids (TDS) and inorganic salt. The cations calcium, magnesium, sodium, and potassium, as well as the anions carbonate, bicarbonate, chloride, sulphate, and, particularly on soil, nitrate, are the most common constituents (agricultural use).

**Result and discussion**

*Diarrhea/Dysentery Less Than 5 Year Age*

The maps in this layer display a four-year comparison of disease data. BHUs in Multan's district are typically divided into UCs. Some Union council in rural areas has two BHUs, but the division of BHUs is based on population as well as Union Council. Diarrhea/Dysentery disorder is prevalent in children under the age of five in Union Councils 57, 83, and 93.

The geographical position of the BHUs in the union councils is depicted in this layer details. 4-year analytical comparative analysis in three major categories of diarrhea dysentery of children below the age of 5. For this analysis, two highest levels of disease, two medium and two lower levels of disease, are selected and the comparative results from 2017 to 2020 for all 4 years are shown. In 2017, the ratio of BHU Bhakar Arbi (SS) was 1265, but by year 2019 it was lowered to 757, but again to 935 in 2019.

The patient ratio decreased to 780 in the last year of 2020. In 2018, the BHU Rana Wahin (MT) ratio was 100 but the ratio was up 168, and last year data shows that the ratio rises to 232. BHU Rana Wahin (MT) has the lowest ratio of patients, like the number of patients visited 133 in 2017.

In the medium-sized BHU Inayatpur, it is a different scenario and a gradual increase in patient ratios each year. In 2017, the registered number of patients was 352, but gradually increased to 395 in 2018 and continued to rise as 454 in 2019, and did not stop increasing as 614 in 2020.

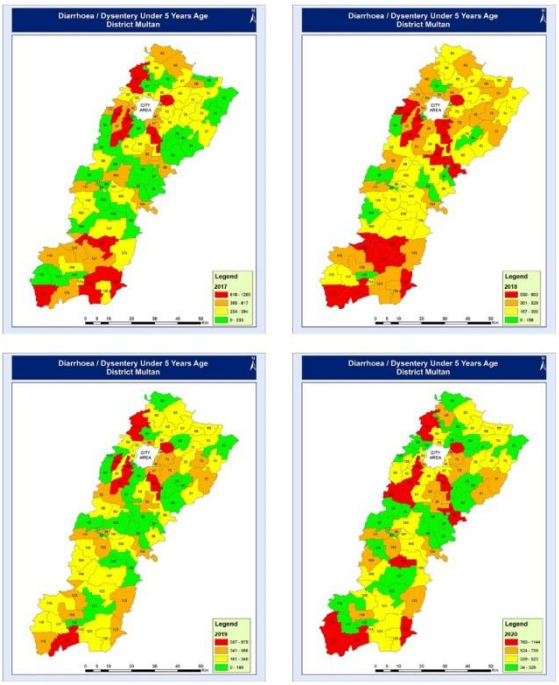


**Fig. 3.** Diarrhea/Dysentery less than 5 year age.

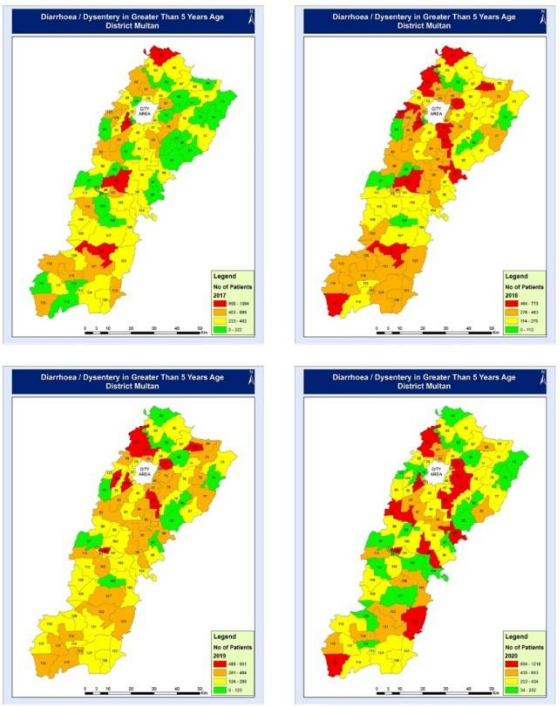


**Fig. 4.** Diarrhea/Dysentery greater than 5 year age.

*Diarrhea/Dysentery Greater Than 5 Year Age*

Union council 128 consistently reveals a high percentage of Diarrhea/Dysentery disease patients over the age of five. The geographical position of BHUs in the union councils is depicted in this layer details. 4-year comparative study in 3 main categories of the diarrhoea dysentery over the age of five years. The comparative results of 4 years, say from 2017 to 2020, show 2 higher levels of disease, 2 medium levels and 2 low levels of disease. In 2017, the patients ratio at BHU Billi Wala (SS) was 637, but in 2018, the ratio rose to 749 and continued to rise as 931 in 2019. The patients ratio increased by 1218 in the last year of 2020. On the other hand the lowest patient ratio in BU Budhla Sant (SR) was 110 in 2017, but 71 in 2018 were registered for BHU. BHU BHU Budhla Sant (SR) was 110. The ratio grew again in 2019 and came to an end in 92, as compared to 2017, but increased from 2018 and now the Fig.s for the previous year show the ratio continues to grow to 156. In the medium-sized BHU Kotla Chakar the scenario was different and the ratio of patients slowly decreased each year. As a result, the number of registered patients decreased in 2017 by 440 in 2018 and again by 319 in 2019 with an increase of 183 in 2020 and an increase of 434 in 2017.

*Enteric/Typhoid Fever*

The majority of BHUs in map have a small patient ratio, but Union Council 117 has a high and moderate Enteric/Typhoid Fever ratio. This layer lists BHUs' location in the union councils. 4-year comparative analysis of the entry/typhoid fever ratio of patients to three main categories of disease chosen. For this analysis, 2 medium, and 2 low-level diseases are adopted and comparative results are shown from 4 years between 2017 and 2020. In 2017, BHU Wahi Khojee recorded the most patient-level ratio, with 53, but the ratio grew 2-fold by 153 in 2018, but by 2019 it dropped to 108, and by 2017 it was higher.

The patient ratio decreased by 86 in the last year of 2020. On the other hand, BHU Buch Khusroabad (BS) had the lower ratio of patients as zero in 2017 and the number of patients registered in 2018 in BHU was only two and the number was zero in 2019, while the number was 1 in 2020. In the BHU Chak No.18/MR (MT), which falls in the medium category, a low-category scenario has been recorded, as in the 2017 zero patient and the same in 2018, but six patients were registered with this BHU in 2019 and a ratio of 59 patients with this very abruptly changed BHU in 2020.

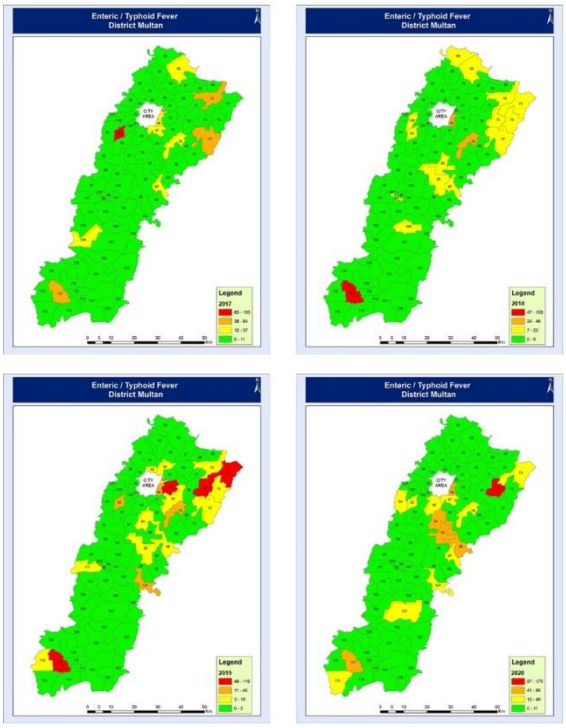


**Fig. 5.** Enteric/Typhoid fever.

*Peptic Ulcer Diseases*

In map, most BHUs have low patient ratios, but Union Council 93 consistently shows a high ratio of Peptic/Ulcer Disease patients. This layer lists the geographical location of BHUs within the union councils. 4-year comparative analyses of the proportion of patients in Peptic Ulcer Disease in three major categories of the disease selected. For this analysis, 2 diseases with the highest, 2 medium and 2 low levels are selected and the results for all four years 2017-2020 are comparatively reported.

The highest patient proportion recorded for Chak No.1/MR (SR) in 2017 was 186, but it was up to 337 in 2018, up to 766in 2019 and gradually up to the highest level 1335 in 2020. in 2016 it is up to 437. In contrast, in 2017, only 8 patients registered for this BHU were BHU Juggo Wale and in 2018 only 2 patients registered for BHU. However, in 2019 the patients registered were zero, and again zero in 2020 this BHU shows that the coping capacity is good in this BHU. In 2019, the patients registered for the first time. In the BHU Basti Malook (MT), which fall into the medium-range, the patient-ratio changes gradually, with 127 patients in 2017 and 271 patient-ratios in 2018 and 427 patients in 2019 and an increase in the patient-ratio in 2020 of 617 patients recorded in t, are indicated by the scenario.

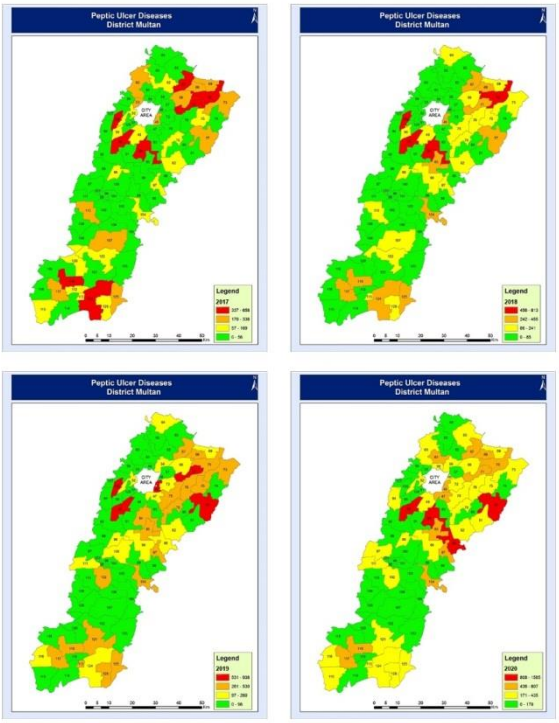


**Fig. 6.** Peptic ulcer diseases.

*Worm Infestation*

In map, most BHUs have low patient ratios, but Union Council 117 consistently shows a high ratio of Worm Infestation patients. This layer lists the geographical location of the BHUs within the union councils. 4-year analysis of the ratio of patients to Worm Infestation Disease in 3 main disease divisions. For this analysis, 2 diseases with the highest, 2 medium and 2 low levels are selected and the results for all four years 2017-2020 are comparatively reported. In 2017 the patient ratio for BHU Wahi Khojee was the highest, 396, but in 2018 the ratio was increased to 857, in 2019 the ratio fell from 644, but in 2020 it was gradually reduced to 377. In contrast, the patient ratio of BHU Chak no.10.T (SR), as in 2017, was only nine, and the patient ratio was only reduced by three in 2018, while the patient ratio was zero in 2019, which was increased to 15 in 2020. The scenario shows the gradual variation in the increase and decrease in the patient ratio in BHU Bhakar Arbi (SR), which fell into the middle category.

The ratio of patients to the BHU as in 2017 was 145, and by the patient ratio in 2018 the ratio fell by 64, with a total of 79 registered in 2019, up from last year, and a very gradually increasing patients ratio by 2020, with 117 registered patients in this BHU.

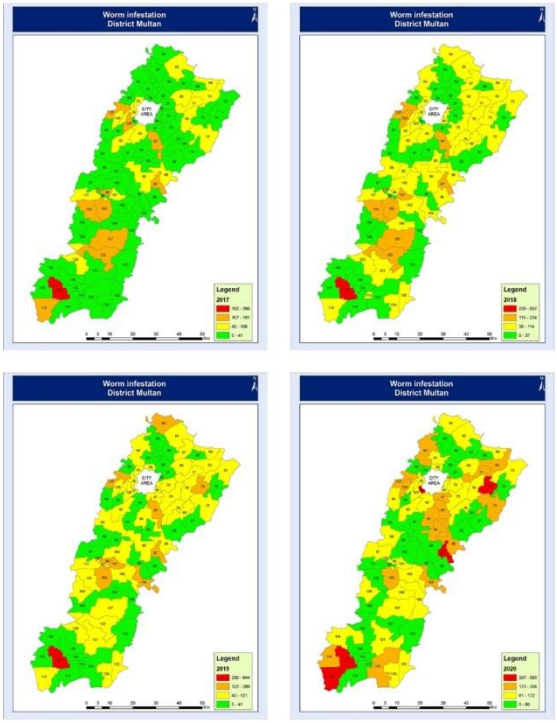


**Fig. 7.** Worm infestation.

*TDS*

This map depicts the degree of TDS in Multan district using data from all 82 BHUs. Just 18 BHUs have excellent drinking water quality, while ten BHUs have very poor (unacceptable) water quality that is unfit for human consumption but is still used. As can be seen in the previous graphs, these BHUs are also in a precarious situation due to the high patient ratio.

The results of the TDS water data have been shown the maps for disease data. However, I have been selected for my research for many elements to justify the five diseases. However, the water component is one of the main sources, which is why the disease increases quickly. For this purpose, the Punjab Health department and Punjab Saaf Paani Company have collected water sample and data that have been tested at the lab. These data contain four kinds of water information I've chosen a component that is water TDS and also a water quality control measuring tool. The map shows the five data type in Fig. 8. The first of these BHUs is low level TDS which shows good water quality and also low-level diseases and the second of those BHUs is medium-level, causes disease but not quickly, but has a high disease ratio. And last but not least, 3rd, which is very high and not suitable to consume, and the diseases and patients of these BHUs are also extremely high.

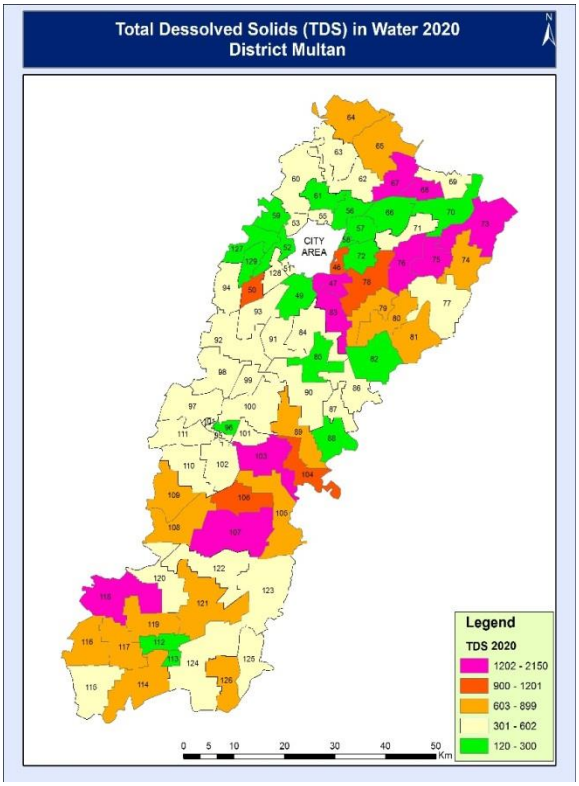


**Fig. 8.** TDS map of 2020 of district Multan.

*Regression Analysis*

*Regression Analysis between Diarrhea (<5 year) and TDS*

The regression/correlation analysis between Diarrhea/Dysentery in 5-year-old patients and TDS shows a strong association, as shown in the map. The majority of union councils are under-predicted because the majority of patients are not reported in BHU records, which is also addressed in data limitations, and we have discovered that people in these areas take precautionary measures, such as boiling the water first or purifying it with filters. However, since there are more patients in these BHUs, some places are likely to be overburdened.

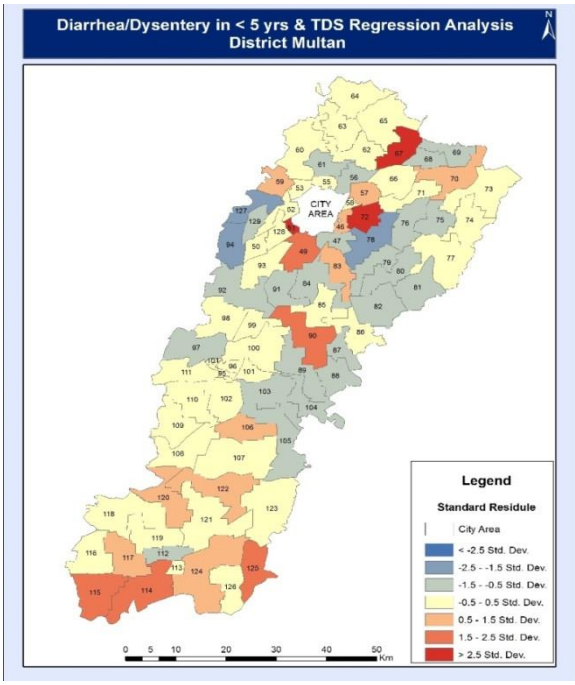


**Fig. 9.** Regression analysis between diarrhea (<5 year) and TDS of District Multan.

*Regression Analysis between Diarrhea (>5 year) and TDS*

Map Fig. 10 depicts the 67 common high values of the Union council, as depicted in the previous map of 4.7. On the diagram, more values are normal predicted, and some BHUs are highlighted as over predicted, demonstrating our findings.

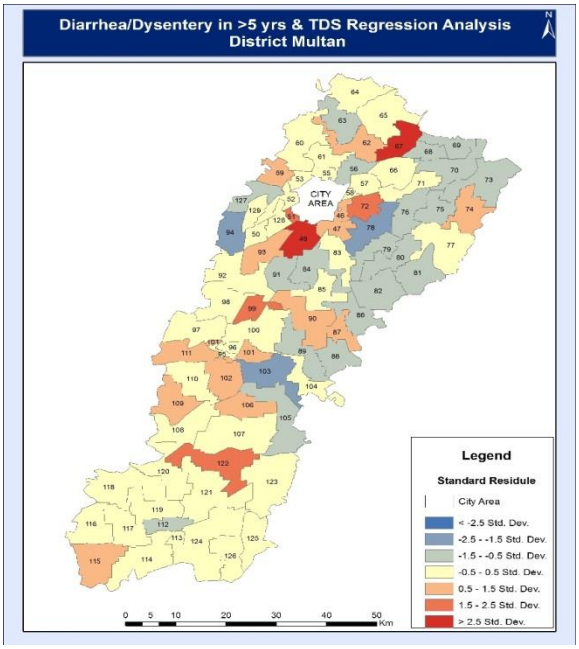


**Fig. 10.** Regression analysis between Diarrhea (>5 year) and TDS of District Multan.

*Regression Analysis between Entric and TDS*

Map 11 depicts the relationship between Entric/ Typhoid disease and TDS of these BHUs. There are less BHUs that are over-predicted, and more that are under-predicted. The disease results match the TDS, implying a similar relationship between the two.

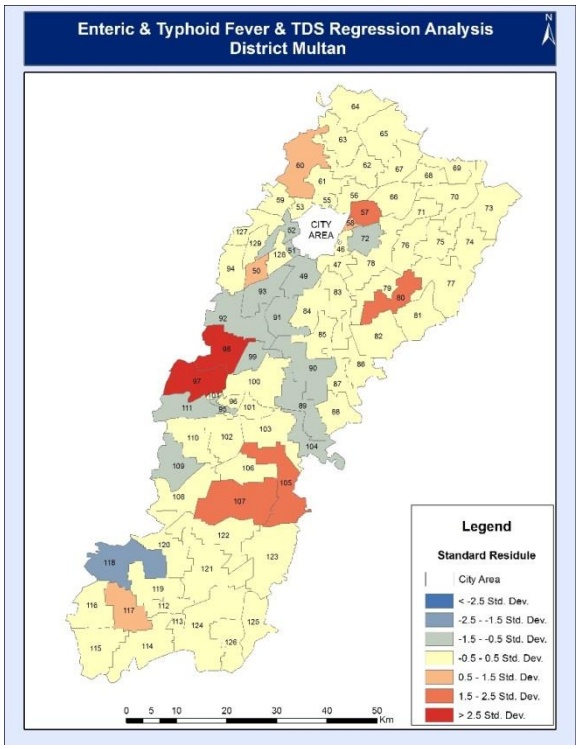


**Fig. 11.** Regression analysis between entric and TDS of District Multan.

*Regression Analysis between Peptic Ulcer and TDS*

The more BHUs that are over expected, the fewer BHUs that are under predicted, as seen in Map 12. The data also matched with TDS data, but certain regions, such as Union Council No. 50, 60, and 90, are more highlighted and in danger because the water quality is so poor.

*Regression Analysis between worm infestation and TDS*

The worm infestation and TDS correlation findings are shown in Map 13, minus the degree of standard deviation, and less expected areas are shown in the BHUs. In these regions, regression analysis indicates a close correlation between diseases and water quality. Infected people ratios have been reported in BHUs, with more cases unrecorded.

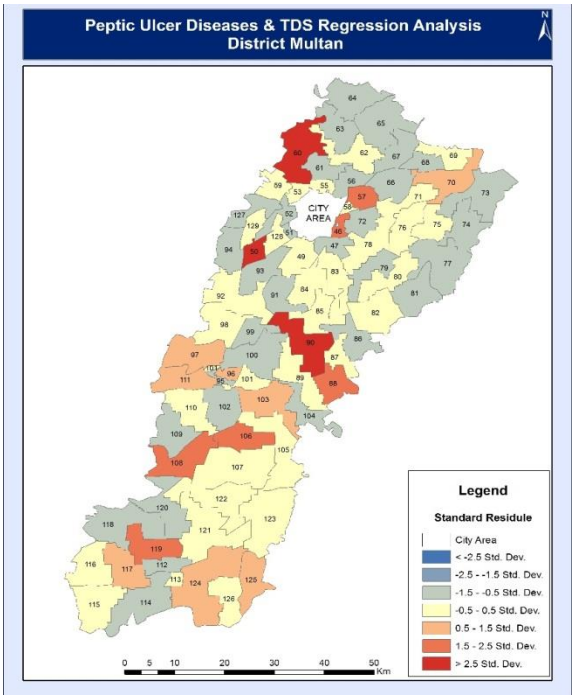


**Fig. 12.** Regression analysis between peptic ulcer and TDS of District Multan.

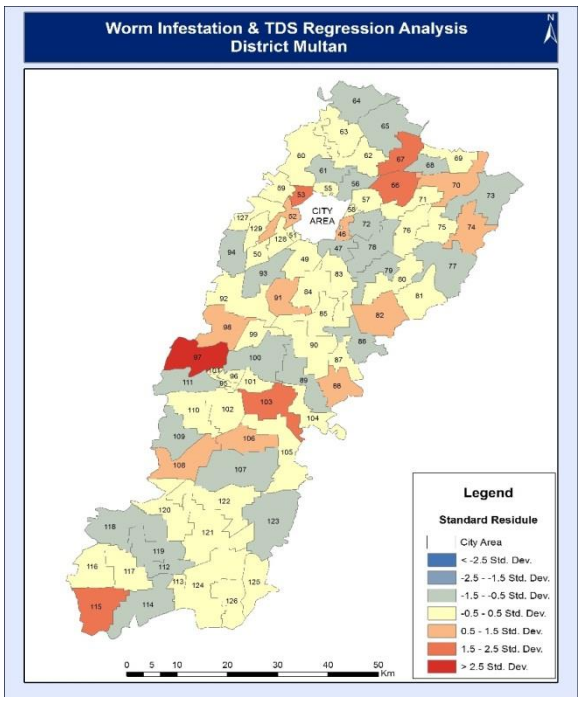


**Fig. 13.** Regression Analysis between worm infestation and TDS of District Multan.

## Conclusion

There are approximately 82 BHUs in Multan District (except Multan City). Five of the most common diseases have been reported in the study area, and they are affecting the population at an alarming rate. These five diseases are distributed unevenly in Multan district, and they affect people in varying degrees. Although the precise number of people who die each year is unclear, health officials believe that it is in the thousands. According to data collected in BHUs, people in Multan die every year as a result of these diseases. This report looks at diseases on an annual basis, as well as a comparative overview of the five diseases to see how many people are affected. In the line graph analysis of 82 BHUs, the cumulative analysis of the patient ratio in the BHUs in the graph form is found as well. The data of the patient is also stored in the GIS map database, which includes variations in the colour scheme. This can easily distinguish between the high and the low annual population of those diseases. The regression methodology in the Arc GIS software justifies the relationship between water and disease in order to compare disease data with water quality, in terms of predicted values and predicted values. The study's main aim is to draw attention to minor yet life-threatening diseases, as well as the most common diseases in backward (unplanned) areas that are remote from cities and lack city amenities.

## Suggestions.

1. The BHUs must be upgraded with advanced medical facilities (equipment).
2. Immediate steps must be taken to ensure safe drinking water in severely impacted areas.
3. Periodic studies must be performed to determine/estimate the quality of life of humans and livestock.

## Acknowledgement

The author thanks the Punjab Health Care Department and Saaf Pani Company for supplying the data for this report. Dr. Ather Ashraf was also instrumental in the author's success.

## Author's contribution

All contributed equally.

## Conflict of interest

Authors declared there is no conflict of interest exists and ready for publishing this manuscript.

**References**

**Abbas I, Auta SZ, Naiya RM.** 2012. Health Care Facilities Mapping and Database Creation Using GIS in Chikun Local Government, Kaduna State, Nigeria. Global Journals Inc. (USA) 12.

**Abdurrahman BI.** 2013. A GIS-based Spatial Analysis of Health care Facilities in Yola, Nigeria. Middle East Technical University Ankara, Turkey.

**Ahmed HA, Badr-Eldin TO.** 2014. Distribution of Health Care Providers in Khartoum State Using GIS Techniques. Dept. of GIS and Cartography, Faculty of Geographical and Environmental Sciences-University of Khartoum.

**Ahmed U.** 2013. Distribution of Primary Health Care Facilities in Kano Metropolis Using GIS (Geographic Information System). Department of Geography, Ahmadu Bello University, Zaria.

**Albert B.** 1992. United States Environmental Protection Agency. July 1992. Secondary Drinking Water Regulations: Guidance for Nuisance Chemicals.

**Amjad D, Kausar S, Aslam RW, Sarwar F.** 2019. Land cover change analysis and impacts of deforestation on the climate of District Mansehra, Pakistan. J. Bio. Env. Sci **14(6),** 103-113, June 2019.

**Andrews GJ.** 2004. Thinking the Dynamics between Healthcare and Place: Therapeutic Geographies in Treatment and Care Practices. Wiley on behalf of Royal Geographical Society (with the Institute of British Geographers) **34.**

**Aslam RW, Saeed U, Mehmood H, Ullah H, Younas I.** 2017. Impure Water, a Future Disaster: A Case Study of Lahore Ground WaterQuality with GIS Techniques. ICGISGDM 2017: International Conference on GIS and Geomatics for Disaster Management. Dubai: World Academy of Science, Engineering and Technology International Journal of Civil and Architectural Engineering.

**Burgert JM.** 2014. Using Geospatial Analysis to Inform Decision Making In Targeting Health Facility-Based Programs. Measure Evaluation, by USAID. **Christopher MB,** 2006. Pattern Recognition and Machine Learning. Springer journal of health and sciences.

**Cressie N.** 1996. Change of Support and the Modiable Areal Unit Problem. Geographical Systems **3,** 159-180.

**Croxton FE, Cowden DJ, Klein S.** 1968. Applied General Statistics, Pitman. ISBN 9780273403159 (page 625).

**Curtis AR.** 1989. Locality Planning for Health Care: A Case Study in East London. Royal Geographical Society (with the Institute of British Geographers) **21.**

**Darren PS.** 2003. Surveying the Uses of Geographical Information Systems in Health Authorities 1991-200. Wiley.

**David PB.** 2012. Incorporating Geospatial Capacity within Clinical Data Systems to Address Social Determinants of Health. Public Health Reports 126.

**Dennis CR.** 1982. Sanford Weisberg Criticism and Influence Analysis in Regression, Sociological Methodology, Vol **13(1982),** pp. 313-361

**Dennis CR.** 1984. Sanford Weisberg Criticism and Influence Analysis in Regression, Sociological Methodology, Vol **13(1984),** pp. 315-321.

**Devon MT, Ouimet C, Menachemi N.** 2015. Using GIS for Administrative Decision-Making in a Local Public Health Setting. Association of Schools of Public Health 127.

**Dietrich CF.** 1991. Uncertainty, Calibration and Probability: The Statistics of Scientific and Industrial Measurement 2nd Edition, A. Higler. ISBN 9780750300605 (Page 331)

**Easterlow SJ.** 2005. The Strange Geography of Health Inequalities. Transactions of the Institute of British Geographers 30.

**Fazlay SF, Theresa M, Doddato Mangum C.** 2003. Utilizing geographic Information Systems in Community Assessment and Nursing Research. Journal of Community Health Nursing 20.

**Fleuret S.** 2011. Networks in local health systems: towards new spaces. Geo Journal 76.

**Fran SE, Boone, Sippel S, Stuart E, Bunn, Bronwyn D.** 2012. Identifying the Spatial Scale of Land Use That Most Strongly Influences Overall River Ecosystem Health Score. Ecological Applications 22.

**Gould MI.** 1992. The Use of GIS and CAC by Health Authorities: Results from a Postal Questionnaire. Royal Geographical Society (with the Institute of British Geographers) 24.

**Habib W, Aslam RW*, Akram MAN, Khalid MB, Abbas W, Tahir MH, Ullah H, Mehmood H, Mirza AI** 2020. "Assessment of Temporal Changes in Landuse Patterns by Incorporating Topographical Parameters". International Journal of Agriculture & Sustainable Development, Vol 02 Issue **04,** pp 99-113.

**Hirschfield A.** 1995. The Spatial Analysis of Community Health Services on Wirral Using Geographic Information Systems. The Journal of the Operational Research Society 46.

**Jonathan DS, Mahbubur R, Rolf D, Klemm, Keith W, West P.** 2007. Development and Management of a Geographic Information System for Health Research in a Developing-country Setting: A Case Study from Bangladesh. Journal of Health, Population and Nutrition 25.

**Kohsaka H.** 2000. Applications Of GIS To Urban Planning And Management: Problems facing Japanese local governments.

**Luo W.** 2004. The contribution of GIS to geographical research. Using a GIS-based floating catchment method to assess areas with shortage of physicians. Health & Place.

**Maantay J.** 2002. Mapping Environmental Injustices: Pitfalls and Potential of Geographic Information Systems in Assessing Environmental Health and Equity. National Institute of Environmental Health Sciences 110.

**McKee E.** 2003. Measuring the Health of Nations: Analysis of Mortality Amenable To Health Care. BMJ: British Medical Journal 327.

**Michael SE, Patricia NA.** 2011. Manuel V., Using GIS to Measure Physical Accessibility to Health Care. World health organization.

**Ocasio MB.** 2007. Urbanization and Spatial Organization: Hospital and Orphanage Location in Chicago, 1848-1916. Oxford University Press 85.

**Paul KJ.** 1982. Hospital Location as a Determinant of Emergency Room Utilization Patterns. Association of Schools of Public Health 97.

**Qingming ZX.** 2008. GIS Based Method to Assess the Shortage Areas of Community Health Service. Research Center for Digital City Wuhan University, Wuhan 430072, China.

**Rashid MT, Aslam RW, Abbas W, Ullah H, Khalid MB, Arshad S, Mirza AI, Tahir MH.** 2020. "Hazardous Effluents and their Impacts on Human Health: Future of Industrial Boom". International Journal of Innovations in Science & Technology, Vol 02 Issue **04,** pp 114-125, 2020.

**Redpath M.** 1996. Health and Deprivation in Cities; Medical Geography Submitted Papers. Royal Geographical Society (with the Institute of British Geographers) 28.

**Short JR.** 2002. The Disturbing Case of the Concentration of Power in Human Geography. Wiley on behalf of Royal Geographical Society (with the Institute of British Geographers) 34.

**Skidmore S.** 1981. Some Comments on the "Calculation of Catchment Populations within the National Health Service" by Gandy. Journal of the Royal Statistical Society. Series D (The Statistician 30.

**Sonam JR.** 2015. Spatio-Temporal Analysis of Spatial Accessibility to Primary Health Care in Bhutan. ISPRS International Journal of Geo-Information.

**Tahir, Muhammad & amp; Ahmad, Sajid & Aslam, Rana & Ahmad, Israr & Ullah, Hameed & Aziz, Aqsa & Zubair, Muhammad Hamza & Mirza, Ali & Hassan Raza, Dr-Syed.** 2020. Critical study of groundwater quality of metropolitan lahore using geo-spatial techniques. Vol **2,** pp 89-105.

**Tanser F.** 2006. Geographical Information Systems (GIS) Innovations for Primary Health Care in Developing Countries. innovations spring

**Thomas B, Richards CMC.** 1999. Geographic Information Systems and Public Health: Mapping the Future. Public Health Reports 114.

**Waters A.** 2008. Using Geographic Information Systems for Health Research. Application of Geographic Information Systems.