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Spatial Distribution and Pattern of Location in Primary Health Centers in West Garo Hills District, Meghalaya

V. Saravanabavan[1], Nokimte N Sangma[2], C Vinothini[3]

[1]Associate Professor, Department of Geography, School of Human and Environmental Sciences, North Eastern Hill University, Shillong -793022, Meghalaya, India.

[2]PG Project Fellow, Department of Geography, School of Human and Environmental Sciences, North Eastern Hill University, Shillong -793022, Meghalaya, India.

[3]Research Scholar, Department of Geography, School of Earth and Atmospheric Sciences, Madurai Kamaraj University, Madurai- 625021, Tamil Nadu, India.

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ABSTRACT

Primary health care services cover a wider range of activities, including medical care, sanitation, infrastructural facilities, immunization, counselling health awareness education, social security, rehabilitation, etc. The West Garo Hills District in Meghalaya, India, is a predominantly rural area that faces significant challenges in healthcare accessibility due to its mountainous terrain, economic constraints, and dispersed population. This study examines the spatial distribution and service efficacy of Primary Health Centers (PHCs) within this region. Utilising GIS-based methodologies, specifically Nearest Neighbor Analysis, this research assesses the clustering, dispersion, and service reach of PHCs across the district. The spatial pattern analysis reveals insights into how healthcare facilities are distributed with population density and socio-economic conditions, highlighting regions with inadequate healthcare coverage. Through mapping and comparative analysis, we identify underserved areas, recommend improvements in the spatial placement of PHCs, and propose actionable steps for policy development. These findings aim to support more equitable healthcare distribution and enhance primary healthcare accessibility for the district's population.

Keywords; Primary Health Centers (PHC)**,** Spatial distribution**,** Nearest Neighbor Analysis**,** Healthcare accessibility Spatial Distribution and pattern of Location in Primary Health Centers in West Garo Hills District, Meghalaya

Introduction

Primary healthcare services encompass a broad spectrum of activities, including medical care, sanitation, infrastructure, immunization, counseling, health education, social security, and rehabilitation **(1,2,3)**. Ensuring the availability of these services is essential to achieving the "Health for All" goal and plays a crucial role in primary healthcare **(4)**. Medical geography examines the spatial aspects of health and healthcare delivery systems, with a particular focus on disparities and accessibility challenges **(5,6,7,8)**. This field emphasizes the importance of geographic information systems (GIS) and spatial analysis methods—such as Nearest Neighbor Analysis—in evaluating healthcare distribution and identifying underserved areas(**9,10,11**) .Research on healthcare accessibility, especially in rural and remote regions, frequently highlights obstacles like geographic isolation, transportation limitations, and economic constraints(**12,13,14,15**). Studies by Andersen and Newman **(16)** and Penchansky and Thomas **(17)** identify the "5 A's" of healthcare accessibility—availability, accessibility, affordability, acceptability, and adequacy—which serve as criteria in evaluating healthcare distribution, particularly in socioeconomically disadvantaged areas(**18,19**). GIS has become an invaluable tool in healthcare planning, offering visualizations of healthcare facilities and their service areas. Studies by McLafferty and Tanser et al. **(20)** demonstrate how GIS can analyze the spatial distribution of healthcare services and identify accessibility issues. The application of NEA, for instance, enables the delineation of catchment areas, revealing potential service overlaps or coverage gaps that can guide the strategic placement of healthcare resources (**21,22,23,24**). Research in mountainous areas, such as the Himalayas and other rural settings in developing countries, indicates that terrain, infrastructure, and economic factors significantly impact healthcare accessibility **(25,26,27**). Additionally, the literature on healthcare accessibility emphasizes that government and non-governmental collaboration is essential to address challenges in healthcare access **(28,29,30).** Bocquier **(31**) advocates for integrated healthcare planning in resource-constrained settings to bridge healthcare distribution gaps and optimize facility locations according to population needs (**32,33,34**). Research using GIS and spatial analysis techniques has proven especially relevant in assessing the distribution of healthcare services in rural and mountainous regions similar to West Garo Hills, Meghalaya. Methods like Nearest Neighbor Analysis and Thiessen Polygons are particularly effective for understanding healthcare accessibility and planning the optimal placement of new Primary Health Centers (**35,36**). Furthermore, research highlights the impact of socio-economic and environmental factors, such as terrain and population density, on the distribution and efficacy of healthcare services in rural India (**37,38,39,40**). Studies focusing on policy recommendations for healthcare access

underscore the importance of policy adjustments based on spatial data and GIS analysis **(41,42,43)**. The targeted healthcare policies can substantially improve healthcare access, especially in challenging terrains like West Garo Hills, where GIS-driven approaches can enhance service accessibility and support informed decision-making.

Study Area

The West Garo Hills District in Meghalaya, India, is a blend of urban and rural regions, with Tura town as its administrative headquarters. Covering an area of 3,714 km², it is situated in the westernmost part of Meghalaya and shares borders with the East and South Garo Hills districts, Assam's Goalpara District, and Bangladesh. With a population of 643,291 as of 2011, it is the second most populous district in Meghalaya, following East Khasi Hills.(Fig 1). The region, characterized by its forested, hilly terrain, relies heavily on agriculture as the primary source of income. Due to widespread poverty, Primary Health Centers (PHCs) are often the only affordable healthcare option, highlighting the need to evaluate the distribution and effectiveness of these facilities. The state of Meghalaya spans 22,720 km², known for its mountainous terrain, valley stretches, and resource-rich highland plateaus. The Garo Hills region, where the West Garo Hills is located, has lower elevations and warmer climates compared to the Khasi and Jaintia Hills.

Objectives

To find out the spatial distribution pattern of PHC in the Study area.

To understand the location efficiency of PHC in the West Garo Hills district

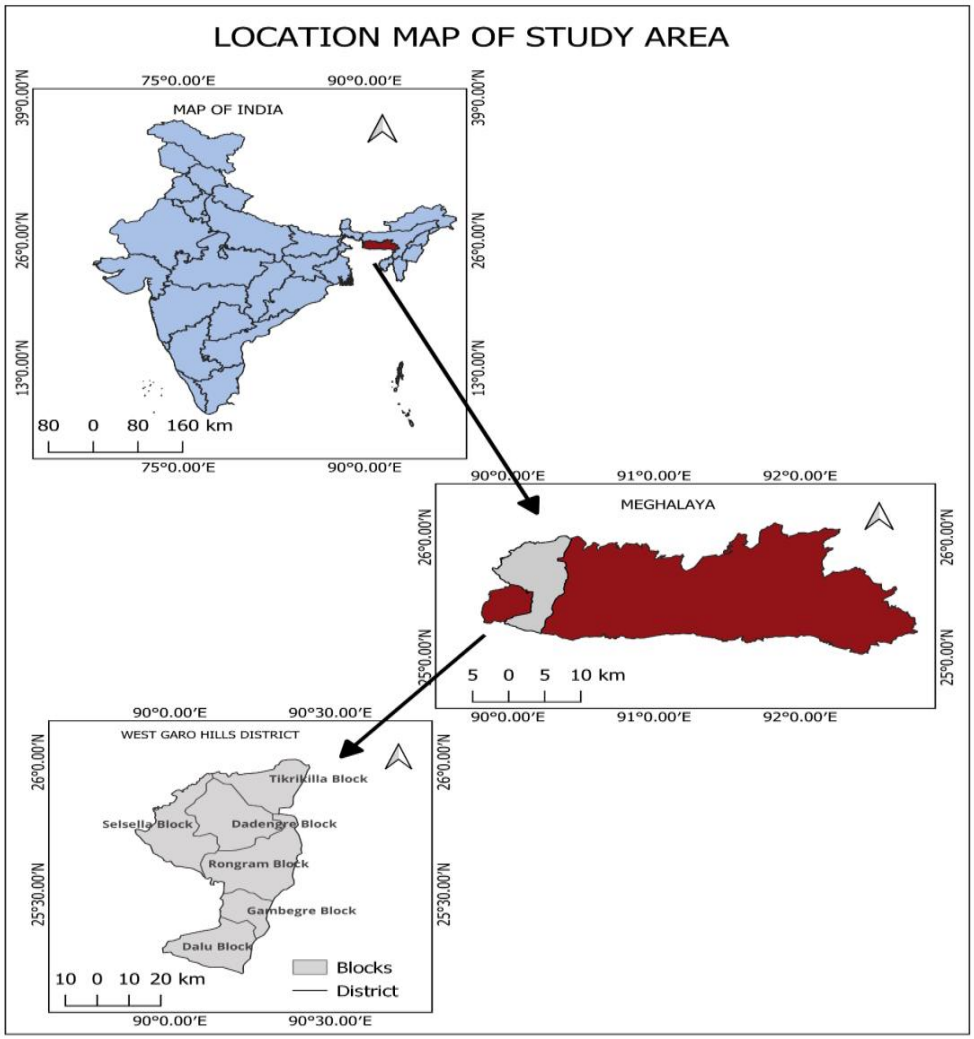

Fig1.Location of the study area

Methodology

Data Collection

Study Area: West Garo Hills District, Meghalaya, India.

Data Sources: Geospatial coordinates and relevant attributes of Primary Health Centers (PHCs) collected from government health databases, field surveys, and GIS data repositories.

Software and Tools: GIS software (e.g., ArcGIS, QGIS) for spatial analysis, and statistical tools for data processing.

Nearest Neighbor Analysis (RN Statistic): Used to determine the spatial distribution pattern of PHCs across the district.

Formula: $RN = \frac{Dobs}{Dexp}$

RN – Nearest Neighbor index of spacing

Dobs - The average of the observed distance between each center and its nearest neighbor in km

Dexp –The expected average distance between each center and its nearest neighbor in Kilometers.

This analysis provides insights into whether PHCs are clustered, dispersed, or randomly distributed, reflecting the planning adequacy of healthcare facilities.

Data Analysis and Interpretation

Mapping and Visualization: Using GIS software, generate spatial maps showing the distribution and service areas of PHCs across the district.

Quantitative Assessment: Analyze the spatial patterns identified by RN Statistic and Thiessen Polygons to evaluate PHC accessibility and coverage comprehensively.

Comparative Analysis: Compare PHC distribution patterns with demographic and socio-economic data to identify correlations between population density, socio-economic factors, and healthcare accessibility.

Assessment of Accessibility and Equity: Insights into the clustering or dispersion of PHCs and the adequacy of their service areas can guide policymakers in identifying areas that lack sufficient healthcare access. Based on findings, propose recommendations to enhance healthcare accessibility, such as adding PHCs in underserved regions or optimizing existing facilities' locations.

Result and Discussion

Identification of Primary Health Centre

This Study represents the characteristic features of the spatial distribution of healthcare centers, which is estimated with the help of Nearest Neighbor Analysis.In West Garo Hills District of Meghalaya Primary Health Care Centres plays an important role for the rural people of the district providing the health needs to them at lower cost. West Garo Hills is divided into six blocks each block having 2 to 3 PHCs supporting the health system of the district. Dalu block has 3 PHCs, namely Dalu PHC, Purakhasia PHC, and Kherapara PHC, giving primary health needs to the nearby villages. Dalu PHC, located in the south, acts as the main center for most of the villages. Villages like Koinabhoi, Koinadubi, Kujikura, etc take 15 to 30 minutes to reach the PHC and supporting them with all the basic health needs being the nearest Primary health care center to them, including all the border area villages also come for health needs to the center. Rongram Block has the highest population concentration with only 2 PHCs namely Asanangre PHC and Babadam PHC serving the rural people of nearby villages. Tura is located under the block of Rongram where most of the private and Government hospitals are located and this hospital plays a vital role for half of the population while PHC supports the other villages which are quite far from the hospitals and can't afford large sums and are very difficult to travel long way, in this way PHC in rongram block help or support them in all necessary health needs. In the same way PHC in other blocks helps people in many ways and they don't have to travel long distances for basic health needs. Most of the PHCs are in the border areas where most of the settlement takes place.

Nearest Neighbor Analysis

Nearest Neighbor Analysis measures the speed or distribution of something over a geographical space (**44,45,46**). It provides a numerical value that describes the extent to which a set of points are clustered, random, or uniformly spaced. Researchers use Neighbor Analysis to determine whether the frequency with which something is observed spatially is comparable with other locations. It can provide researchers with a numerical value for the clustering of a geographical phenomenon, allowing this value to be compared more accurately with other places. (Table 1).

The nearest neighbor analysis is an approach to the study of point, line, and area patterns. In this approach, one makes tests on measurements of distance between sampled points and their nearest neighbors by comparing the observed mean distance. we can measure the distance of each point from its nearest neighbor, i.e., which is closest to it. We then calculate the value Rn, where.

A Nearest Neighbor Analysis is a descriptive statistic that shows a pattern of locating features by comparing graphically the observed nearest neighbor distance **(47,48)**. That is, it describes a phenomenon based on its distance from another phenomenon in space. The Nearest Neighbor Analysis does not only examine distance points, but it also examines the closest point to it. The Nearest Neighbor Index (NNI) is a complicated tool to precisely measure the spatial distribution of a pattern and see if it is regularly dispersed, randomly dispersed, or clustered. The Nearest neighbor analysis an effective for quantifying distribution and decreasing distribution patterns of health care centers such as primary health centers and sub-centers. Which could be located and pointed on maps on a particular scale nearest neighbor statistic.

$$RN = \frac{Dobs}{Dexp}$$

RN – Nearest Neighbor index of spacing

Dobs - The average of the observed distance between each center and its nearest neighbor in km

Dexp –The average distance between each center and its nearest neighbor in Kilometers.

$$Dexp = \frac{1}{2\sqrt{N/A}}$$

N – Number of Health centers

A – Area

The nearest neighbor technique involves the measurement of the distance from an individual point to its nearest neighbor irrespective of any diversion. A series of such distance measurements are made using all the individual points present on a randomly selected sample and the value of mean distance (Do) to the nearest neighbor that would be theoretically expected if the individual of that population were randomly distributed is calculated using the formula.

$$Dexp.DE = \frac{1}{2\sqrt{N/A}}$$

0-cluster, 1-random, 2.15-uniform

Table 1: Nearest Neighbor Analysis

S. No.	Nearest Neighbor	Distance in cm	Distance in km Ground
1	1-2	2.4	10
2	1-3	2.3	5.75
3	3-4	2.9	7.25
4	4-6	2.5	6.25
5	5-6	2.8	7
6	5-7	2.8	7
7	6-7	2.5	6.25
8	6-8	2.8	7
9	8-9	1.9	4.75
10	8-10	2.2	5.5
11	9-10	2.1	5.25
12	10-11	1.9	4.75
13	11-12	3.5	8.75
14	12-13	3.7	9.25

Source; Compiles by author

Nearest Neighbour Analysis

$$RN = \frac{Dobs}{Dexp}$$

RN = 1.79

Figure 2 shows the characteristics feature of the spatial distribution of healthcare centers, which is estimated with the help of nearest-neighbor analysis. The spatial distributions of health centers in the study area are found to be satisfying the health needs of the population concerned. They are randomly distributed in the study area, serving corner.

Spatial Distribution of Primary Health Care Centres, Service Access and Role of Distance in Spatial Accessibility

The spatial distribution of Primary Healthcare Centers concerning the surrounding villages and their rural population presents a marked variation in its locational pattern. Looking at the randomly distributed primary health center in the West Garo Hills district rural people are bound to have good accessibility to healthcare facilities mostly in the southern part of the district as most of the PHC is in that area. (Fig 2). Thus, the spatial patterns of distribution of PHC reveal that the existing locational arrangements of the Primary Healthcare centers are efficient. While on the northeastern part of the district, people must travel quite a distance for the access of health care services it takes some time to reach the PHC to access health care services which have a negative impact on the locational efficiency of primary health care centers.

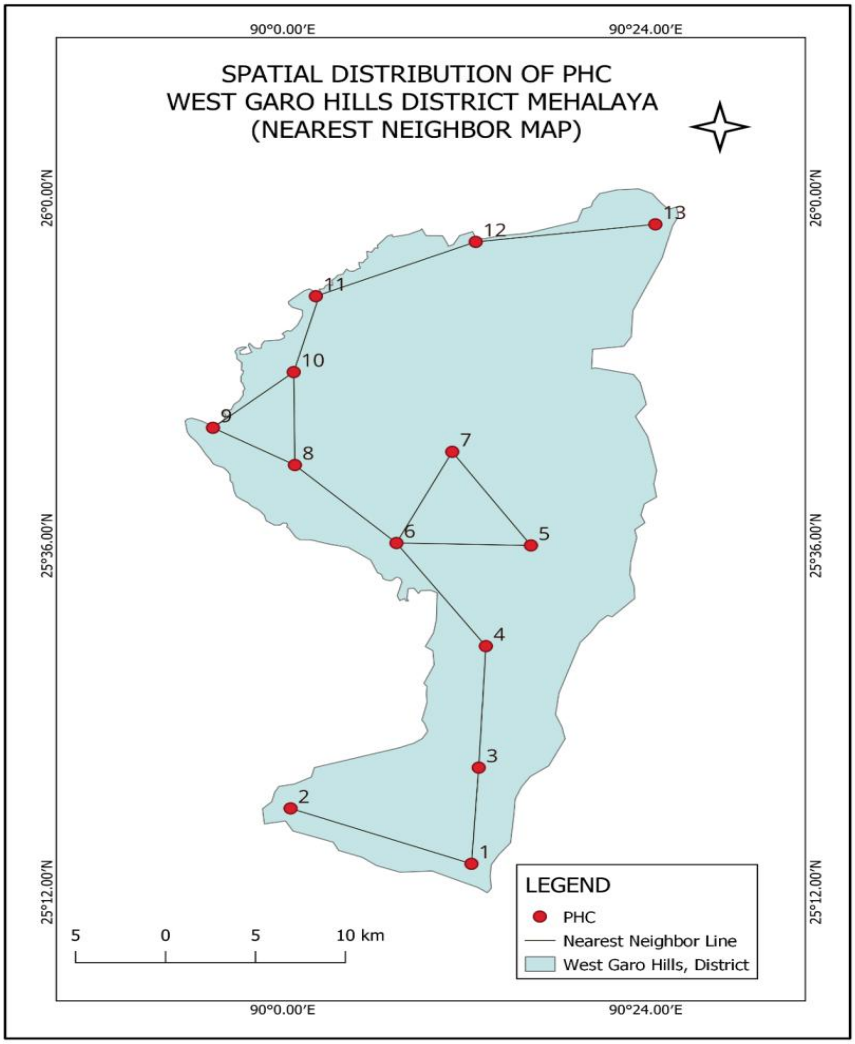

Fig.2 Spatial Distribution and Nearest Neighbour Analysis of PHC-Meghalaya

In the southern part, it is also revealed that the existing PHCs have a good service for the surrounding villages compared to the middle and northeastern part of the district where people must travel quite a long distance just to access the health care services and are not efficient for the surrounding villages.

PHCs existing in the western part of the district such as Jeldupara PHC, Selsella CHC and Bhaitbari PHC have good accessibility of healthcare services although they are in the border areas they give enough services to the surrounding villages. At the same time PHC like Dalu CHC, Purakhasia PHC and Kherapara PHC also have good accessibility of healthcare services, people don't have to travel a long distance and it requires less amount of time and

have good road connectivity to reach the PHC and access to all the health necessities. This shows how efficient the location of this PHC is for the surrounding villages and serving them a good amount of health care services. On the other hand, Primary Health Centre such as Phulbari CHC, Tikrikilla PHC, Dadengre CHC people surrounded by this PHC must travel a quite long distance to access the necessary healthcare services which requires a minimum of about 30-40 minutes to reach the destination which is maybe due to bad road connectivity or due to less transport facilities making it difficult for the people of those areas. The place is also hilly terrain areas where the construction of Primary Health Centre cannot take place easily due to poor supply of necessities. Babadam PHC can be considered as the best location for serving the surrounding villages with equal amount of healthcare necessities as it is in the middle where people from all the surrounding villages can equally access to the service which is efficient for the people of that area. This shows how the distribution of Primary Health Care Center plays an important role in serving the people and how efficient it is for the surrounding areas making it available for all kind of healthcare services.The locational efficiency of the Primary healthcare centers in the present study thus helps towards a general understanding of the health facility locations through a series of examination of utilization patterns of the respondents.The effect of distance on medical care utilization forms an important concern in the rural areas. Distance and its effect confirmed the validity of inverse care law in most cases. The availability of good care tends to vary inversely with the need for it in the population served. This is clearly revealed in the present study in many of the cases of consumer travel pattern for a particular general health service as well as for special health care services.

This highlights the fact that mobility decreases with increase in age thus proving the hypothesis that old age groups are more likely to use local facilities. The different utilization of special health care services of higher order can be accomplished by the differences in social status of respondents, differences in service availability and accessibility, age differences and different service type. This point of view is clearly confirmed in the present study while analyzing the consumer movement for special health care utilization.

Conclusion

This study concludes that the distribution of Primary Health Centers (PHCs) in the West Garo Hills District is generally adequate but reveals disparities, particularly in the northeastern part of the district. PHCs in the western areas exhibit efficient service coverage, while those in the northeast face accessibility challenges due to limited connectivity and fewer health centers. This uneven distribution affects accessibility, affordability, and adequacy of healthcare for some rural populations. Enhancing accessibility in underserved areas through improved infrastructure, additional PHCs, and support from government and NGOs can bridge these gaps, ensuring broader healthcare access across the district.

References

1.Tanser, F., Gijsbertsen, B., & Herbst, K. (2006). Modeling and understanding primary health care accessibility and utilization in rural South Africa: An exploration using a GIS-based accessibility model. Health & Place, 12(4), 701-714.

2.Vinothini, C., Suja Rose, R. S., & Saravanabavan, V. (2024). Assessment of primary health care accessibility and patients' perception in Madurai district: a geo-medical study. *GeoJournal*, *89*(5), 211.

3. Saravanabavan, V., Vinothini, C., & Rose, R. S. (2023). Spatial distribution of primary health care centre and socio-economic conditions of patients in Madurai district. *International Journal of Geography, Geology and Environment*, *5*(2), 192-198.

4. World Health Organization (WHO). (2008). Primary Health Care: Now More Than Ever. World Health Report 2008. Geneva: WHO.

5. Saravanabavan, V., Balaji, D., Reshma, C. U., Sheheersha, S. K., Sudharsan, R., Vimala Vinnarasi, J., ... & Balasubramani, K. (2021). Urban disease ecology and its spatial variation of Chikungunya in Madurai City, Tamilnadu, India: a geo-medical study. GeoJournal, 86, 2335-2350.

6. Saravanabavan, V., Balaji, D., & Preethi, S. (2019). Identification of dengue risk zone: A geo-medical study on Madurai city. GeoJournal, 84(4), 1073-1087.

7.Saravanabavan, V., Eswari, S., Vimala Vinnarasi, J., Ganesan, J., & Sudharsan, R. (2020). Spatial temporal variation of leptospirosis disease in Madurai city–Medicogeographical analysis. *International Journal of Geography, Geology and Environment*, *2*(1), 21-7.

8.Mukherjee, S., & Sarkar, S. (2020). Socio-economic determinants of healthcare access in rural India: Implications for spatial planning. Social Science & Medicine, 250, 112864.

9. Rana, P., & Gupta, P. (2017). Environmental and socio-economic factors affecting healthcare accessibility in hilly areas:

10. Saravanabavan, V., Sudharsan, R., Balaji, D., & Rahamath Nisha, R. (2014). Patient's perception and epidemiological characteristics of dengue in Madurai city-using factor analysis. *International Journal of Mosquito Research*, *1*(2), 18-24.

11.Vinothini, C., Saravanabavan, V., & Emayavaramban, V. (2022). Location Accessibility of PHC and Health care travel performance in Madurai District. *International Journal of Innovative Science and Research Technology. ISSN*, (2456-2165),

12. Sharma, M., & Jain, A. K. (2019). Spatial patterns of primary healthcare facilities and accessibility in India: A GIS-based approach. Journal of Health and Place, 58, 102218.

13.Khatun, F., & Sinha, R. (2018). GIS-driven policy recommendations for healthcare infrastructure improvement in northeast India. Indian Journal of Medical and Health Research, 42(3), 327-336.

14. Saravanabavan, V., Reejo, R. J., Neethidevi, A., & Jayashree, R. (2006). Travel and health care utilization pattern of patients in Vadippati panchayat union: A micro-level study using GIS. Journal of Deccan Geographer, 44(2), 97-108.

15.Vinothini, C., Saravanabavan, V., & Balaji, D. (2021). Travel pattern of health utilization to primary health care centres in Madurai district. International Journal of Geography, Geology and Environment, 3(2), 144-151.

16, Andersen, R., & Newman, J. F. (1973). Societal and individual determinants of medical care utilization in the United States. *The Milbank Memorial Fund Quarterly. Health and Society*, 95-124.

17.Penchansky, R., & Thomas, J. W. (1981). The concept of access: definition and relationship to consumer satisfaction. Medical Care, 19(2), 127-140

18.Saravanabavan, V., Reshma, C. U., & Preethi, S. (2021). Determinants of reproductive health in working women in Thrissur district, Kerala. GeoJournal, 86, 239-253.

19.Saravanabavan, V. (2013). Patients' perception and travel behavior pattern in primary health care center in Haripad block-A micro Geo-medical study. *Journal of Language in India*, *13*(4), 194-207.

20.McLafferty, S. (2003). GIS and health care. Annual Review of Public Health, 24, 25-42.

21.Saravanabavan, V., Aneesh, P., Babu, H. M., & D Harieswari, M. (2021). Patient's perception and level of primary health care utilization in east block of Madurai North taluk: A geo-health study. *International Journal of Geography, Geology and Environment*, *3*(1), 34-41.

22. Saravanabavan, V., & Abeesh, P. (2020). Environmental health status of fishermen in Mahe district. *International Journal of Geography, Geology and Environment*, *2*(2), 95-102.

23.Vinothini, C., Neethidevi, A., & Saravanabavan, V. (2019). Health impact and nine fold classification of land use change in Nilakottai Taluk, Dindigul District, Tamil Nadu. *International Journal of Geography, Geology and Environment*, *1*(1), 80-86.

24.Vinothini, C., Saravanabavan, V., & Rose, R. S. (2024). Travel patterns of adult patients to primary health centers in Madurai district: A public health perspective.

25.Ezeh, A. C., et al. (2021). Addressing rural and remote access to healthcare services in low and middle-income countries. Global Health ActionSpatial , 14(1), 1862367.

26.Kumar, P., & Sharma, R. (2016). Distribution of health services in India: An analysis of primary health centers. Journal of Public Health and Epidemiology, 8(3), 76-84.

27.Saravanabavan, V. (1997). Geo-Medical analysis of Multibacillary Leprosy in Tamil Nadu. *The Deccan Geographer*, *35*(2), 179-189.

28. Vinothini, C., & Saravanabavan, V. (2022). Spatial Distribution of Emerging Diseases in Madurai District: A Geo Medical Study. *International Journal of Innovative Science and Research Technology*, *7*(6), 2456-2165.

29.Saravanabavan, V., Vinothini, C., Balaji, D., Alok, M., Arya, M., & Athira, R. (2022). Geo-spatial approach on COVID 19 mortality in Tamil Nadu. International Journal of Geography, Geology and Environment, 4(1), 123-131.

30.Adekunle, A., et al. (2020). Health care accessibility and policy challenges in developing countries. International Journal of Health Planning and Management, 35(2), 292-302.

30.Roy, S., & Sarkar, A. (2017). Application of GIS in evaluating healthcare accessibility in rural India: Case studies from Himachal Pradesh. International Journal of Health Geographics, 16(1), 20.

31.Bocquier, A., et al. (2014). Improving geographical accessibility to healthcare in rural areas: Evaluation of spatial policies in rural France. Health & Place, 30, 50-58.

32. Saravanabavan, V. (2011). GIS analysis of pedestrian problem and spatial risk areas for each buffer zone in urban cities a case study of Madurai city in Tamlnadu, India.

33. Saravanabavan, V., Lekha, C. A., Aparna, T., Nisha, R. R., Balaji, K. K., & Kanna, S. V. (2021). Spatio-temporal variation of dengue in Kozhikode District, Kerala: A medico geographical study. *International Journal of Mosquito Research*, *8*(1 Part B), 130-140.

34.Vinothini, C., & Saravanabavan, V. (2023). Determinants of health care facilities and patients' accessibility to PHC in Madurai district. *International Journal of Geography, Geology, and Environment*, *5*(2), 17-22.

35.Singh, V., & Singh, P. (2018). Nearest Neighbor and Thiessen Polygon methods in healthcare accessibility: A case study of rural health centers in Uttarakhand, India. Geographical Review of India, 80(2), 203-214.

36.Kumar, A., et al. (2014). Geographical accessibility and equity of healthcare services in India. Geospatial Health, 9(2), 229-238.

37.Bhagat, R. B., & Das, K. C. (2015). Healthcare accessibility and utilization in the rural regions of India. Indian Journal of Geographical Research, 40(2), 133-147.

38.Sharma, R., & Thakur, R. (2021). Policy recommendations for equitable distribution of health facilities in rural India. Journal of Health Policy and Planning, 36(7), 1024-1035.

39.Saravanabavan, V., Emayavaramban, V., Thangamani, V., Manonmani, I. K., Rose, R. S., Balaji, D., ... & Vinothini, C. (2023). Spatial variation of covid-19 morbidity status and identification of risk zone in Tamil Nadu (India) during first wave. *GeoJournal*, *88*(2), 1341-1354.

40.Saravanabavan, V. (2000). An analysis of pattern of leprosy and regional classification of Health Care service in Tamilnadu. *Geography Review of India*, *62*(4), 379-386.

41.Balaji, D., Saravanabavan, V., & Katturajan, K. (2024). Geo-modeling approach of determinants of Chikungunya and its spatial distribution pattern in Madurai city, Tamil Nadu, India. *GeoJournal*, *89*(3), 109.

42.Saravanabavan, V., & Shanmuganandan, S. (1996). Pattern of leprosy treatment and health care situation in Tamil Nadu. *Annals of the National Association of Geographers, India*, *16*(2), 25-35.

43.Saravanabavan, V., & Shanmuganandan, S. (1994). Geo-Medical analysis of Leprosy patients in Tamilnadu. *The Indian Geographical Journal*, *69*(2), 135-139.

44.Saravanabavan, V., Vinothini, C., & SujaRose, R. S. (2024). Transport accessibility and efficiency of PHC location in Kanyakumari district, Tamil Nadu. *International Journal of Science and Research Archive*, *11*(2), 1342-1351.

45.Saravanabavan, V., Lekha, C. A., Aparna, T., Nisha, R. R., Balaji, K. K., & Kanna, S. V. (2021). Spatio-temporal variation of dengue in Kozhikode District, Kerala: A medico geographical study. *International Journal of Mosquito Research*, *8*(1 Part B), 130-140.

46.Saravanabavan, V., Balaji, D., Rahamath, N. R., Preethi, S., & Vadivel, S. (2020). Geo-ecological association of dengue disease in Madurai city-using multivariate analysis.

47.Saravanabavan, V., Keerthi, S. P., Anupama, A., & Vinothini, C. (2019). Psycho-social characteristics of mental disorder patients in Thiruvananthapuram District: A geo medical study. *International Journal of Geography, Geology and Environment*, *1*(2), 08-16.

48.Sudharsan R, Saravanabavan V. Availability and Utilization of Primary Healthcare Centre in Thanjavur District, Tamil Nadu. International Journal of Scientific Research in Science and Technology; c2019. p. 288-97. DOI: https://doi.org/10.32628/IJSRST196451