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Accessibility and Utilization of Comprehensive Sickle Cell Disease Service Centers among Tribes of Nilgiris, Tamil Nadu: A GIS Approach

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Abstract: ***Ensuring equitable access to health services and improvement of living standards of tribal population with Sickle Cell Disease in Nilgiri district of Tamilnadu is an important issue in the district. This paper analyses the physical barriers with accessibility changes for various terrain features using Geographical Information System. Data was obtained from Non-Governmental Organization who service SCD patients (n 1748) in Nilgiri district. Slope, road networks, land use land cover, health centers and villages that were mapped as layers and converted to rasters. A buffer distance of 1 to 5 km interval was created to identify the hamlets within 5 km. An accessibility model was created using cost- distance to identify the travel time. Accessibility model shows that road, slope and land use land cover friction layers influences the travel time and act as major barrier. The average of 2 hours travel time was spent by the tribes overcoming the barriers. This study highlights vulnerable areas in Nilgiris district where health services facilities are lacking. The travelling time and distance obtained through accessibility model can be used for decision making and alternates suggestions***

Keywords: Sickle Cell Anemia, Health inequities, Accessibility, GIS

1. Introduction

Access to health care is an important part of an overall health system and has a direct impact on the burden of disease that affects many countries like India in the developing world. Achievement of this issue requires the identification and removal of the many barriers like physical, economic, social and cultural which hinder access to health services. Access to health services can arise due to one or different combinations of these four barrier types. In case of physical barrier factors explaining health inequity are landscape terrain, climatic conditions and environmental factors which add difficulties in geographical distance. Accessibility by the tribal people residing in Nilgiri district is a far more major problem. The geographic distance is also an important factor in a large country like India with limited means of communication [1]. The health circumstances of indigenous peoples vary according to the unique historical and social characteristics of their particular environments, as well as their interactions with the non tribal populations they reside. Furthermore, disparities in quality of care are pervasive, especially for ethnic minorities with lower socioeconomic status that residing in some geographic regions [2] .It is well known that availability and distribution of health care resources in rural areas are scarce [3].

The tribes usually live in low standard accommodation and under less favourable living conditions and health [4] .The tribes with poor transportation facilities and the physical condition where they live appear most significant obstacle to healthcare. The place of residence is of primary importance, especially in rural areas, since rural dwellers encounter many barriers, such as long travelling distances when accessing health care services [5], [6]. In Nilgiri district the utilization of health services is mostly influenced by the factors such as climate, forest cover, slope, road networks and land use land cover pattern.

Individual with Sickle cell disease are at risk of unexpected, intermittent and life threatening complications (i.e. pain, joint necrosis and major organ damage). For patients with sickle cell disease, the variability and unpredictability of pain may create an additional barrier to adequate health care. Pain from sickle cell disease is difficult to characterize and is often undertreated [7], [8]. Patients may be seen by health care providers as seeking excessive narcotic pain medications, potentially leading to adversarial relationships and mistrust. Understanding these barriers may help clinicians provide high-quality care to patients with sickle cell disease.

1.1 Geographical and Environmental factors as barriers in health access

Most of the tribes in Nilgiri district living in rural areas are exposed to a variety of geographic and climatic barriers such as mountainous terrain, large bodies of water, travelling conditions or extreme cold that may prevent them from accessing their usual source of health care. While most rural hospitals are located in more rugged terrain, or in areas where populations are less dense, they are much farther apart making it difficult for the tribes to access the health centres.

Another important environmental factor is rainfall, the continuous heavy rains in Nilgiri hills can lead to numerous landslides and cause extensive damage resulting in uprooted trees that can block the road and become impassable to vehicles. Hence, transport is drastically affected and accessibility to healthcare is a major problem to these tribes. The tribes with SCD suffer from pain crises which can worsen the pain during the raining reason may need timely treatment. Hence, the harsh climate along with poor

infrastructure can make it a challenge to provide medical services.

1.2 Distance

The outcome of any disease is influenced by delay in decisions to seek healthcare which represents, timely arrival at appropriate, diagnostic and treatment services. Measures of geographical access to health care can be either area-based or distance based. However in many studies, the utilization of health facilities diminishes with distance [9]-[13] and the quality of transportation and road conditions (EOC Survey). Studies have shown that a major factor in the utilization of health services is travel time and [14] defined that travel time exceeding 30 minutes as unacceptable in accessibility studies [15].

1.3 GIS as a tool for depicting health inequity

Health care decisions are strongly influenced by the type and quality of services available in the local area and the distance, time, cost, and ease of travelling to reach those services [16]-[18].Hence for better management, GIS is being used to create optimal measures of geographical access and to analyze geographical inequities in access as well as those patterned along social and economic lines. GIS can also access utilization of health centres determining optimal locations of health facilities and in helping public health organizations understanding population health and make decisions with the powerful tools.

Hence, the present study assesses the level of availability of health services in Nilgiri district and the factors that hinder tribal people from accessing these services in the study area. Our study is planned to identify the vulnerable areas and factors that contributes to inequity in use of health services in Nilgiri district using accessibility model. This can led to better treatment outcomes and also recognise the need for comprehensive management strategies addressing health access issues.

2. Study Area

The Nilgiri district is one of the smallest district of Tamil Nadu. The district is hill area of 2549.0 sq.kms located between 11° 10' and 11° 30' N latitude, between 76°25' and 77°00' E longitude at the junction of Eastern and the Western Ghats. The district comprises six taluks viz., Udhagamandalam (864 km^2), Gudalur (505 km^2), Coonoor (229 km^2), Kundah (316 km^2), Pandalur (231 km^2) and Kotagiri (401 km^2). The six tribal communities found in the district are Todas, Kotas, Kurumbas Irulas, Paniyas, and Kattunaikkans. Physiographically the district is uneven and undulating terrain owing to hilly tracts which is surrounded by hard boundaries in the form of large reserve forest, water body and commercial farmlands like tea plantations. There are 29 Primary health centres (PHCs) in Nilgiris district in which two health centres are affording treatment for these tribal affected with sickle cell disease.

2.1 Preparation of database and analysis in the GIS

This study includes both trait and disease cases of Sickle cell anemia registered between 1997 to 2012 (n1748) which was drawn from AHWINI (Association for health welfare in the Nilgiris) and CTRD (Centre for Tribal Research Development) and NAWA (Nilgiris Adivasi Welfare Association). The total tribal population of Nilgiri district was 32813 inhabitants. Data inputs such as populated places, health facilities location, land use land cover ,slope and road network were used for the present study.Population density were created using Arcgis 10 to highlight the location of highest tribal population in the district. The health care location and tribal SCD cases locations were geo-coded and generated as point layer. Road networks were digitized using Survey of India (SOI) toposheet 58 A /2, 6, 7, 8, 10, 11, 12, 13 and 15 at 1:50, 000 and categorized as primary, secondary and track. Based on a review of similar studies [19]-[22] travel speed was calculated Table 1. A road friction layer was created based upon the reclassified road. Euclidean distance was then used in combination with reclassified road raster and health centre to analyze the cost distance. Similarly, the land use land cover map was generated using IRS-1D, LISS-III 2009 with ENVI Version 4.1 software. Finally the area calculation for various categories of landuse-landcover was done and reclassified. Average speeds of vehicle across different land cover types were estimated based on [19], [23].Finally the slope layer was derived from Shuttle Radar Telemetry Mission (SRTM) elevation data. A percent slope surface was created in ArcGIS 10 using DEM with spatial analysis toolset and reclassified as nearly plain, gentle slope, moderate slope, steep slope and very steep slope. In the accessibility model, slope is used as a speed-reducing factor.

Table 1: Average travel time on different road surfaces

Road type	*Average Speed limit*
Primary roads	30 km hr-1
Secondary roads	15 km hr-1
Tracks	10 km hr-1

2.2 Accessibility surface model

For the present study accessibility surfaces were generated using the cost-distance function in the ArcGIS environment. Euclidean distances between each road network and the nearest public health facilities were computed. Secondly, a cost-distance analysis was carried out with slope and land use land cover as friction surface. The friction layers were reclassified so that the value of each cell is represented as speed in minute using raster calculator. The friction components were then merged into a single friction surface by assigning weightage of influence .Finally the cost-distance function was applied to calculate time to access the specified health centre (Figure 2.1).

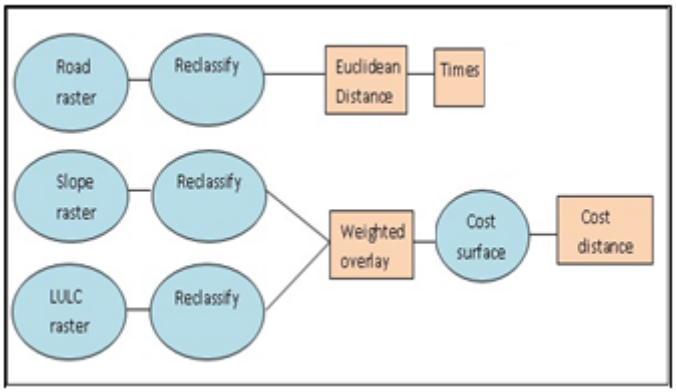

Figure 2.1: Shows the Accessibility model of the Travel Time

3. Results

Here we present our findings starting with an assessment of the current distribution of population density and health facilities in Nilgiri district. The population density of each revenue village was calculated based on population by the total geographical area of the village and is presented as Figure 3.1. The population density of the district was 1962.79 sq.kms of land area with Allimoyar, Kallampalayam, Erumad and Srimadural being the most densely-populated neighborhoods and Nedugula, Bikkatti, Mulligur, Naduvattam, Tuneri and Thummanatti having low population density.

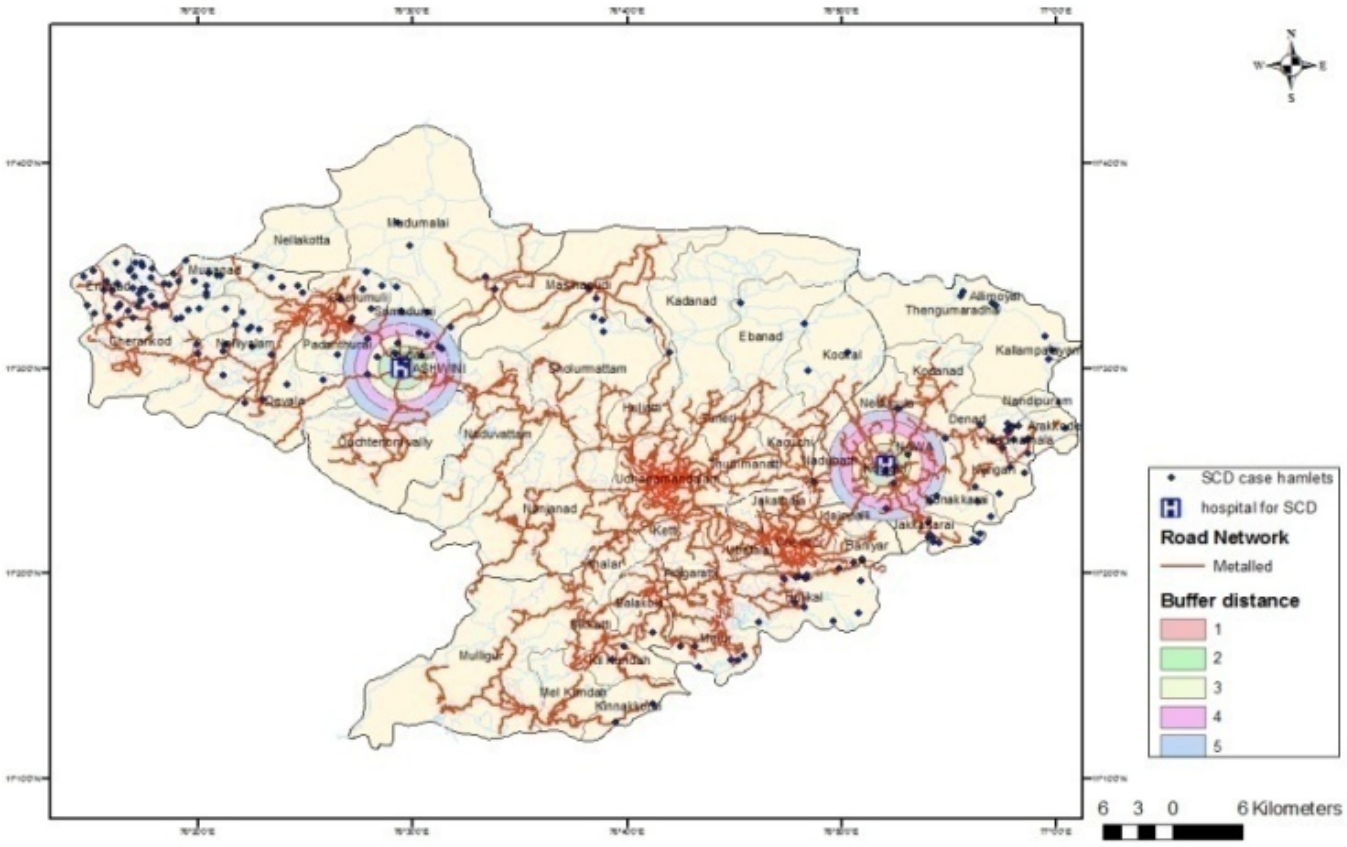

Figure 3.1 Population Density and prevalent of SCD cases of Nilgiri District of Tamil Nadu

Population density was considered an important attribute because interventions to improve healthcare access need to be in areas that can impact the largest number of at-risk community members. Population density map were checked against the rates of SCD patients which found to be directly proportional to the overall population density.

3.1 Distance travel for Health centre

Barriers to transportation in rural areas compound access problems are traditionally experienced by the respondents [5],[6].The average road distance travelled for health care was 35.8 Km. Since Nilgiri district is hilly region travel burden is the major barrier for these tribal people. It was observed that the average of two hours thirty minutes devoted by the respondents across the time. Therefore analyses upon the spatial relationship between the SCD patients settlement and health care institutions serving these tribes are important for identifying the tribal hamlets which comes under 5 kilometer distance interval from the health centre. For this, the proximity of residential areas of these tribes to the health care institutions within five kilometers of the study area was identified primarily by creating multiple ring buffer zones around these facilities (Figure 3.2).

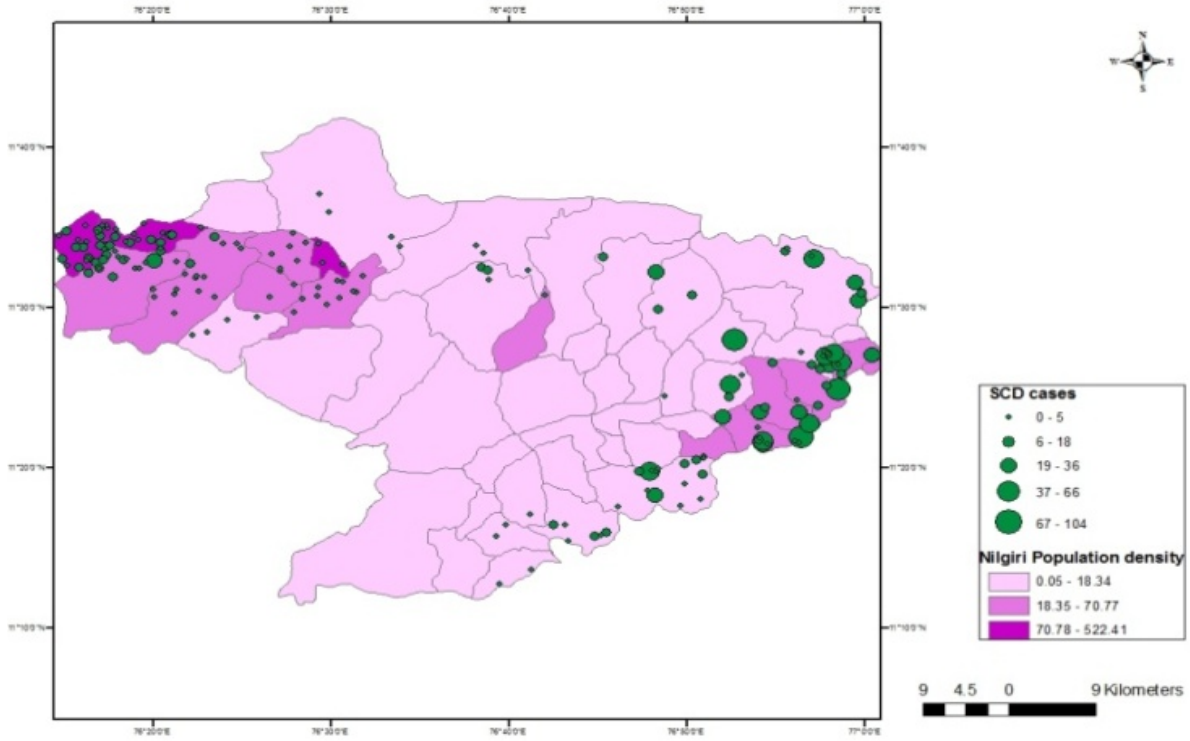

Figure 3.2 Multiple ring buffer Zones for Health Centers

It was observed from the result that of the total 185 tribal hamlets, seven hamlets is located within 1 km of distance, fifteen hamlets within 2 km, twenty five hamlets within 3 km and 4 km and five hamlets within 5 km from the hospitals. Majority of the hamlets was not in acceptable distance from the health centers. This proximity is of great importance especially for emergency situations of these SCD patients because the patients have to rush hospital as soon as possible for immediate intervention when they are under crises of pain.

3.2 Travel time distribution using Accessibility modeling

The results of the travelling cost in terms of time was created using the accessibility surface model of the Nilgiri region, based on Euclidean and Cost distance analysis. The results of Euclidean distance is shown in (Figure 3.3) .It appears that most of district is well covered with roads except for boundary regions which are covered with reserve forest .The analysis shows that the cost is fairly even and very few hamlets are inaccessible to road network. From the result it is observed that an average of 40 minutes is dedicated to reach the health centres through road network.It was also inferred that there were no proper road facilities to access the primary care in northern and north eastern part where the region is covered with dense forest.

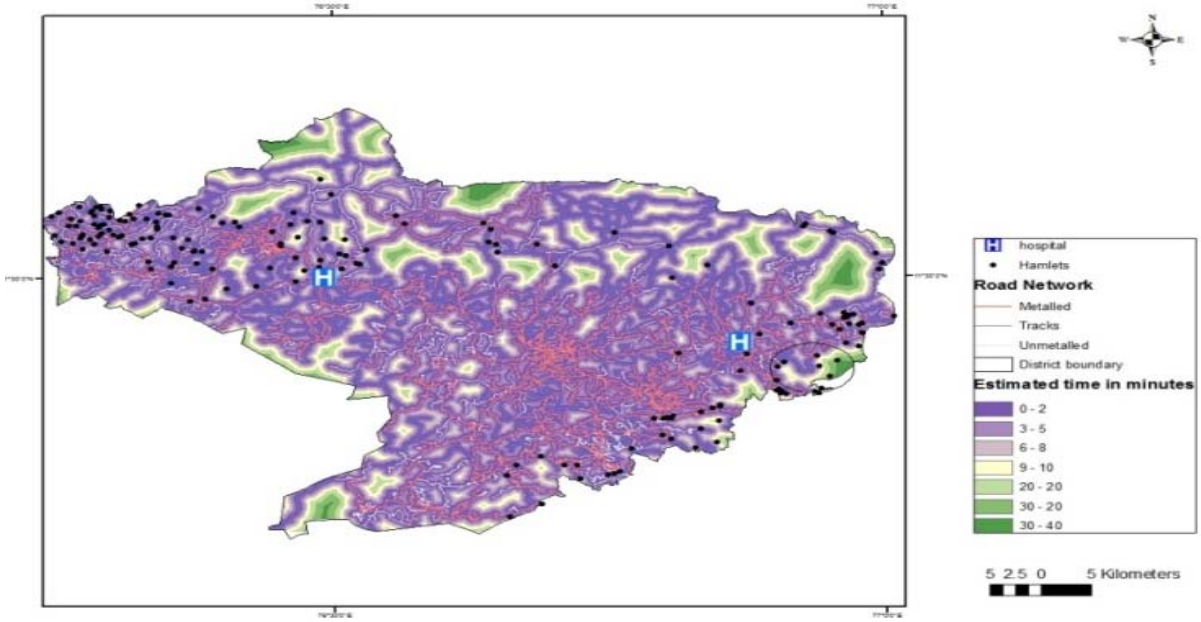

Figure 3.3 Travel time to health centres by Euclidean Distance model

This may be one of the reasons for long travel time.Euclidean distances can overestimate the tribal population that is within 1-hour of a health facility using transport network, elevation and other natural barriers which can provide more accurate estimates [24] and are used here with cost- distance analysis.

The cost-distance function estimates for each cell is the time required to reach the nearest destination ie., is health centre. Travel time is calculated over a friction surface that takes into account the road network, land cover and slope. The Figures 3.4 illustrate that accessibility is evidently changed over different terrain surfaces of the district which in turn impact the tribal population in accessing the health care. The population with least access to health care can be determined by overlaying the tribal settlements on the accessibility map. From the output, it is observed that a distinct cluster was identified in the western part of Nilgiri district where access to a health centre was found to take in an excess of 8 hours travel time mainly of impedance due to the dense forest highlighted as black ring. The easily accessible hamlets within 1 hour travel time consist of 18 villages. Several settlements that were inaccessible since slope and land use land cover that impede the access to health care.

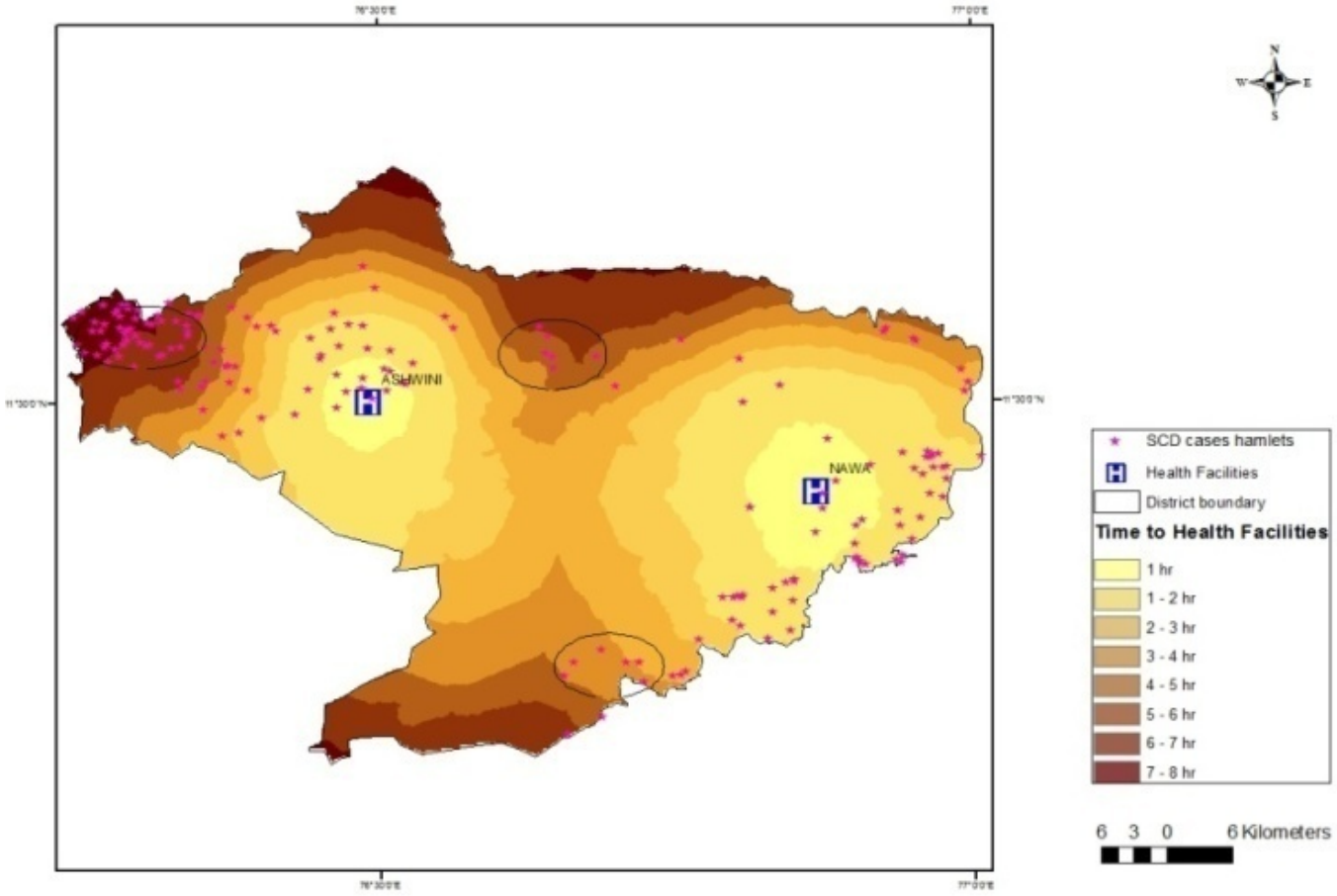

Figure 3.4 Changes in Accessibility to Health Facilities in Nilgiri District of Tamil Nadu

The maximum travel time defined for a patient that requires access to a particular health facility depends upon the severity of his/her condition. In the context of this study, the maximum travel time permitted was established as 1 hour so as to be able to identify the parts of the region where accessibility is worse. Majority of SCD patients live greater than 1 hours of travel time to the health centres attributable to high population concentration. The output clearly delineates the area where high level of impedance corresponding to the barriers.

3.3 Affected Population

Since distance to facilities is a key determinant for access [25], [26] outreach programmes or good transport, roads and communication networks are important to reach physically isolated groups, such as the scheduled tribes. The threshold values were 30 minutes as presented by [14] .The figure 3.5 shows the distribution of the SCD cases into three accessibility groups.

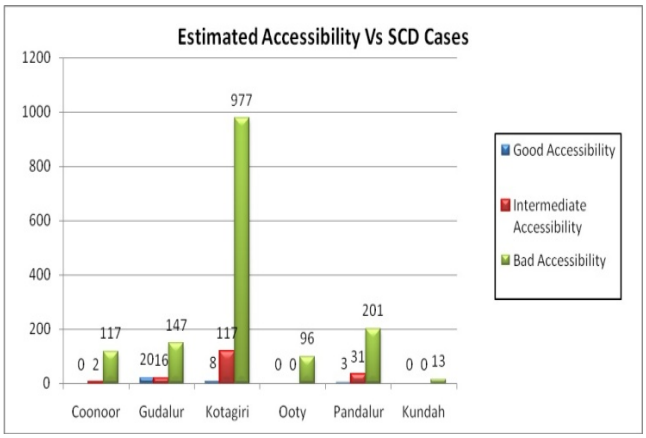

Figure 3.5: Affected populations by the estimated accessibility in each taluks of Nilgiri District

Highest number of cases comes under bad accessibility in Kotagiri taluk however, the intermediate accessibility was observed with highest people living in good accessibility

conditions are transferred into the intermediate and bad accessibility group.

3.4 Impact of Age group on travel time to Health centres

Health outcome can also determine by the factors such as gender, age, caste, education and geography. While considering the distance, age is an important factor in determining health care needs. Health needs of adolescents and the elderly are significantly different. Here the travel time categories as 0-5, 5-15, 15-45and 45 above. The highest number of cases was recorded in the age group of 15-45 (n=194) followed by 0-5 and 5-15 age interval (Table 2). Travel burden more likely affects these people where they have to travel two hours are longer to reach the centre. Those living closer to the health centre were accessing the health centre frequently regardless of age and gender. In Nilgiri district, public transportation is virtually nonexistent, with bus services running only between the main cities. Most of the tribal villages are remote and their transport is mainly by foot.

Table 2: Age group associated with travel time to health centre

Age group	Travel time	Female	Male
0-5	1-30 minutes	21	18
	31-60 minutes	28	51
	> 60 minutes	16	25
5-15	1-30 minutes	40	42
	31-60 minutes	83	102
	> 60 minutes	55	50
15-45	1-30 minutes	98	70
	31-60 minutes	280	212
	> 60 minutes	178	144
45+	1-30 minutes	17	30
	31-60 minutes	55	47
	> 60 minutes	44	42

4. Discussion

Recent years it is noticed that there is a burgeoning interest in the geographical and spatial aspects of the analysis of health care systems. This study highlights critical areas in Nilgiri district where health services may need to be improved using travel time estimates eliminating all the barriers to represent access time. The results of the travelling cost in terms of time and distance conveys that central hamlets of the study area are relatively accessible. Both Euclidean and cost-distance analysis as compared to southern and northern villages. It is clearly evident that topography plays a direct control on accessibility to health centres the western, northern and southern hamlets shows inaccessible to health centres with topography acting as barriers. Analysis using both Euclidean distance and cost distance using GIS methods of measurement has revealed that the tribal people who were able to access road networks were impeded by geographical conditions (slope and land use pattern speed reducing factor).

The study identified limited accessible zones which can be used to locate placement of new health facilities based on tribes with sickle cell disease and realistic travel time. The findings help us to eliminate the identified barriers and can improve the access to health services across tribal groups. Through increased understanding about the overall problem of access; the knowledge of common barriers to health care; the awareness of specific barriers to health care; the decision makers will be able to give solutions to the problem of access with the help of GIS map outputs.

Though AHWINI in Gudalur and NAWA in Kotagiri is however a facility established to monitor the disease cases through mobile outreach in spite of these influencing factors. These health planners aim at developing health policy and services that address geographical and social inequalities in health, and therefore should benefit from evidence-based approaches in health service provision [1].

5. Conclusion

In our study social and geographical inequities in health care use were observed among tribal groups between different geographic areas. Limited road facilities are observed in high incidences areas. Addressing the difference in the travel burden among tribes based on age and gender will require health planners for resource allocation. This study has also showed the feasibility of using GIS technology for monitoring and evaluating the alteration process and the degree of equitable access to services. Findings of our study will help address spatial decision support system for planners for an effective decisions regarding management of healthcare facilities within the tribal area. The future scope of the study is, to evaluate the alternative measures to alter the health service and setting guidelines to optimize decisions on location allocation to make access more equitable with the use of GIS techniques.

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