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Exploring Healthcare Disparities in Palakkad, Kerala: Geospatial Insights for Sustainable Development

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Abstract

Healthcare disparity remains a pressing concern in developing nations, exerting significant strain on local communities, especially those in rural and underprivileged areas. This challenge impedes the ability of these populations to uphold a satisfactory quality of life and hinders their access to healthcare on an equitable basis. This study delves into the healthcare service disparities across various blocks of Palakkad, the largest and one of the most economically challenged districts in Kerala's health sector. The spatial variation of people living with health care facility is in complex nature with in the district due to its multidimensionality and identifying that facilitates location specific strategic planning in health services. Hence statistical analysis was used to compute composite multi scores using two different methods such as index-based composite disparity assessment and Principal component Analysis based composite disparity assessment. GIS maps are also being used to explore the problem area identification. The results revealed that Ottapalam and Attapadi were the blocks with high developments in health care facility and blocks with medium health care development were Sreekrishnapuram, Thrithala, Kollengode, Kuzhalmannam, Palakkad and Chittur. Blocks with low levels of health care facility development were noticed in Mannarkkad, and Malampuzha, Nenmara, Patambi and Alathur. This study sheds light on the spatial disparity, inadequate availability and affordability of healthcare services in Palakkad's blocks. This research emphasizes on the need for improvements to align with basic-needs approach as envisaged in 2030 agenda for Sustainable Development Goals. Significant positive transitions in health system are needed in weaker areas to make it better resilient and prepared to handle health threats in the future.

Keywords: Health care sector; Disparity in health care, Health care services, Indices method, Principal component analysis.

Introduction

Building resilience in health care systems is vital for developing countries, owing to the potentially increasing severe health impacts in recent times. WHO suggests an integrated approach to building and rebuilding health systems that serve the needs of the population. The key ingredients required to make the system resilient in any country encompasses a high-performing health system oriented to primary health care, the ability to sustain essential health services equitably to its population even during an emergency, and investment in the essential public health functions (WHO, 2021). By fostering fair and long-lasting health outcomes, universally health care sector could aid in the achievement of the sustainable development goals (SDGs) (Acharya et al, 2018). SDG 3 is designed to ensure healthy lives and promote well-being for all, at all ages. Health Mission of India government prioritizes national wellbeing.

This influential definition provided a basis on which the World Health Organization defined health as a “state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity”(World Health Organization, 1946).The health strategy of the nation includes the restructuring of health infrastructure, developing man power for healthcare center and improving the accessibility to healthcare services. Healthcare is defined as a program of services that should make available all facilities of health and allied services necessary to promote and maintain the health of mind and body (Agnihotri, 1988). Healthcare is an assembly of services rendered to individuals, families and communities. It is a concern for fellow human beings. The agents of health services or professionals are there for promoting, maintaining and restoring health. Healthcare includes medical care, which refers to the medical services that are provided directly by physicians or paramedical staff (Lakshmi, 2009). The aim of the healthcare is ultimately to provide better health conditions to all individuals. Therefore, Healthcare resource distribution has been studied at different scales ranging from micro to macro level. The purpose of such analysis is usually to examine the nature and

equality of distribution of healthcare resources among rural vs. urban or affluent vs. poor. In recent times, the study of regional variations in the distribution of healthcare services has captured the interest of geographers, planners and other scientists, because of their general interest in the spatial variation of phenomena on the earth's surface.

The term 'health disparities' or alternatively 'health inequalities,' came to occupy a central place in the larger health literature in just the first four years of the twenty - first century. For instance, a keyword search on the two terms in the 1980s and 1990s combined yielded a modest two dozen articles contrasted to more than 400 such articles between the period 2000 to 2004 (Adler 2006; Adler & Rekphof 2008). Development thinkers, health practitioners, health policy - makers, and academicians have engaged considerably with the issue of health inequality (Joseph & Philips 1984; Jones &Moon 1987; Liaw et al. 1989; Macintyre et al. 1993; Macintyre & Soomans, 1995; Curtis &Jones 1998; Mitchell et al. 1998; Curtis 2004; Pearce et al. 2006 & 2008).

Geographic variation in population, and population need for health care, provides the foundation for analysis and planning of health services. People are not spread evenly across the Earth's surface, and populations differ along many dimensions - including age, gender, culture, and economic status—that affect their need for health care, their ability to travel to obtain health care, and the types of services they are willing and able to utilize. Increasingly, GIS is being used to map and explore geographical variation in need for health services and to develop innovative indicators of health care need (McLafferty, 2003). Health is a basic element of every citizen in a country. The well-being of the people is an important foundation of the prospective nation. The health of the people is determined by many factors, however, the role of healthcare resources are very significant. Healthcare resources include practitioners such as physicians, nurses, health maintenance organizations etc. Spatial analysis is the geographical approach to understand inequalities in healthcare services. An important issue of equitable service distribution is the contrast between need for services and demand for them (Meade and Earickson 2006). Social inequalities in health exist in almost all countries. Numerous studies have provided evidence on the persistence of social variations in health in European countries (Drever & Whitehead 1997; Marmot &Bobak 2000; Mackenbach& Bakker 2002; Marmot &Wilkinson 2005). Access to healthcare requires that there is an adequate supply of health services available to a population. According to this dimension, access to healthcare is concerned with the opportunity to obtain healthcare when it is wanted and needed. The availability of healthcare resources is measured traditionally using indicators such as the number of doctors or hospital beds per unit of population. However, there is limited empirical evidence on the spatial disparities of health care facilities available in Palakkad district, Kerala. The study makes an attempt to examine the current distribution and level of inter-regional variations in public healthcare resources in the study area

Study area

Nestled at the foothills of the Western Ghats, Palakkad district serves as the northern gateway to Kerala. Spanning between $10°20^{I}$ N to $11°14^{I}$ N latitude and $76°20^{I}$ E to $76°54^{I}$ E longitude (figure 1.1), it shares borders with Malappuram district to the North and Northwest, Thrissur to the South and Southwest, and Coimbatore district of Tamil Nadu to the East. Among Kerala's 14 districts, Palakkad stands out as one of the five districts without a coastline. Its geographical location, rich history, predominantly rural landscape, educational institutions, tourist attractions, and diverse developmental activities contribute to its unique identity. Palakkad is also one of the largest revenue-generating districts in Kerala. The origin of its name has various interpretations, with some attributing it to the combination of 'Pala' (barren land) and 'Kadu' (jungle), while others connect it with the ancient Jain temple in the area, owing to the significance of 'Pali' as the holy language of the Jains. However, the prevailing belief is that the name 'Palakkad' derives from the indigenous 'Pala' tree that once densely populated the region, earning it the moniker "the forest of Pala trees." The district comprises thirteen development blocks and four municipalities, with ninety-one panchayats grouped into these blocks. According to the 2011 census, the density of population of the district is 627 Sq.km with a total area of the Palakkad district is 4482 Sq.Km. Total population as per the 2011 census is 2.8 million, with a sex ratio of 1000: 1067. Population density of Pattambi Taluk (1268 sq.kms) is the highest followed by Ottapalam (971sq.kms) and Palakkad Taluks (859 sq.kms).

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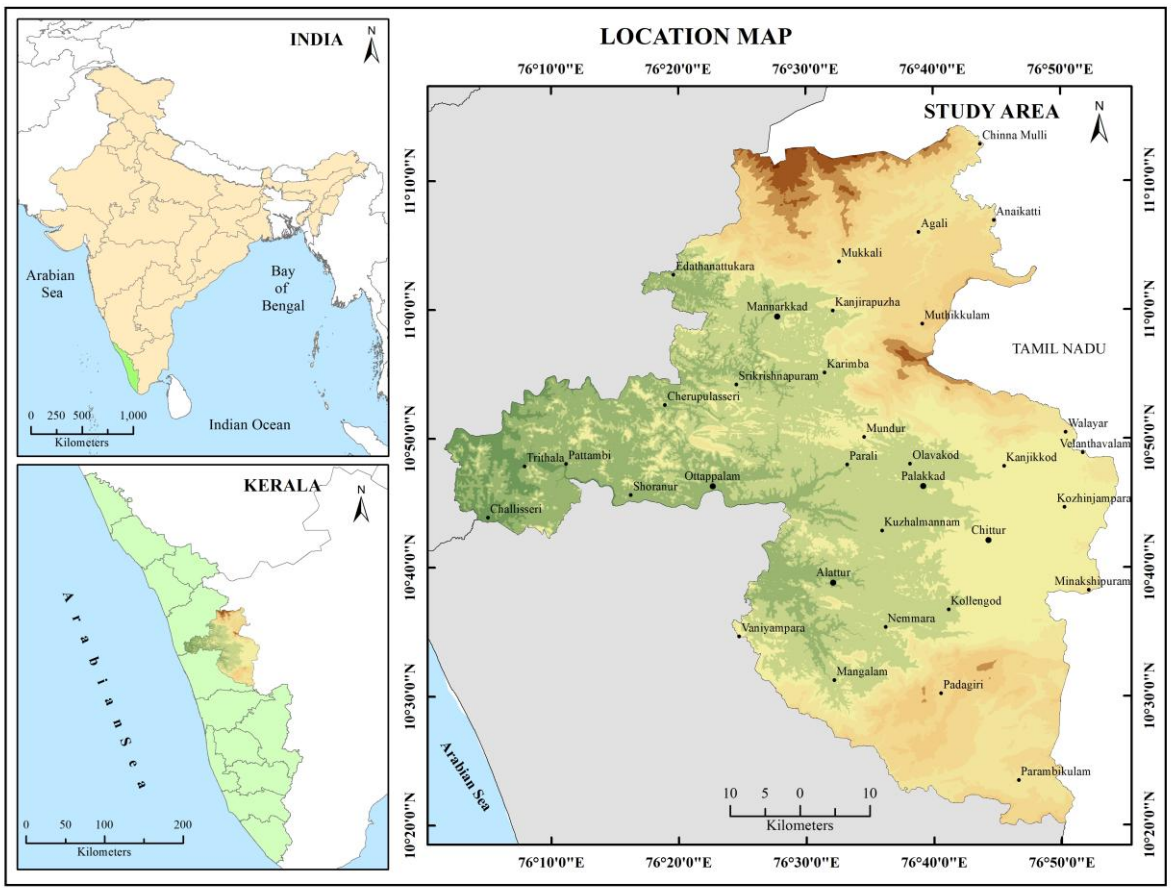

Figure 1.1 Study area

Materials and Methods

There are many researchers attempted to study the regional disparities in health and economic developments. Sankaranarayan and Karunakaran (1985) endeavored to present a regional economic profile of the Kerala state. Thomas George (1988), in his study on regional disparities in Kerala's economic development, aimed to analyze the regional variation in Kerala's economic development. Anand Raj (1997), in his study, sought to gain a deeper understanding of the development process in Kerala, particularly at disaggregate levels. N.J. Kurian (2000), in his research, assessed disparities in terms of demographic indicators, female literacy, state domestic product, poverty, development and non-development expenditure by the state government, shares in the 13th plan outlay, investments, banking activities, and infrastructure development.

Index Based Analysis of the health care disparity

Here the administrative blocks are taken as the unit of the study and analysis is made to find out the status of administrative blocks in Palakkad district. There are four municipalities in the district and for the convenience of the study these are added to corresponding blocks. The analysis is made based upon broad sectors like healthcare. Three methods are employed for comparing levels of development across regions. These include (a) the simple ranking method, (b) the indices method, and (c) the composite index method. Under the simple ranking method, each block is assigned a rank based on the values of various indicators, and these individual ranks are then aggregated to determine the overall rank for the district. In the indices method, the health development index for each block is computed by considering selected indicators, with each indicator's value represented as a percentage of the average value of that indicator at the district level. Combining the sectoral indices of development, the composite index of health development is estimated at the block level.

Table.1.1 Following are the health care indicators used in the analysis:

Sl. No	Indicators used	Unit
1	Number of PHCs and dispensaries	per lakh of population.
2	Number of PHCs and dispensaries	per 100 sq.km of area
3	Number of CHCs	per lakh of population.
4	Number of CHCs	per per 100.sq.km of area
5	Number of allopathic doctors	per lakh of population.
6	Total number of No. of Hospital beds	per lakh of population.
7	No. of Ayurvedic and Homeopathic dispensaries	per lakh of population.
8	No. of Ayurvedic and Homeopathic dispensaries	100 sq.km of area.
9	No. of Ayurvedic and Homeopathic doctors	per lakh of population.

Combining the sectoral indices of development, the composite index of health facility is estimated at block level. A total of 25 indicators are selected for the study. The study is based on the secondary data. The secondary data required for the analysis were collected from (1) Economic review, State Planning Board, Thiruvananthapuram. (2) Department of Economics and Statistics, Palakkad, (3) District Industrial development centre, Palakkad, (4) Census of India – 2011, Kerala series (5) 'A hand book of Palakkad district' – published by the Department of Public Relations, Palakkad district. The tools used in the study are simple and involve the use of elementary statistical Techniques.
Formula used for index calculation is as follows….

Weighted Coefficient of Variation = $Vc = \frac{\sqrt{\sum_{k=0}^{n} (y - Yi)^2 \text{ ni/n}}}{\text{Y!}}$ ……(Eq. 1)

Vc =Weighted Coefficient of Variation
Y= Index Value for the block
Y*i*= Index Value of the district
n =Population of the block
Ni= total district population
Composite indices are used when there are number of variables with different units are used together and indexed in order to make comparisons possible. A composite index is prepared averaging the individual scores of all nice indicators. This is mapped in order to get an overall picture of spatial variations
Composite Index (CI) = ……(Eq. 2)
Multivariate analysis of the health care disparity
The second method used in the analysis is multivariate technique. This method is used separately for transforming a set of related (correlated) variables into a set of unrelated (uncorrelated) variables that account for decreasing proportions of the variation of the original observations. The rationale behind the method is an attempt to reduce the complexity of the data by decreasing the number of variables that need to be considered. If the first few of the derived variables (the principal components) among them account for a large proportion of the total variance of the observed variables, they can be used both to provide a convenient summary of the data and to simplify subsequent analyses.
The Statistical Packages for Social Science (IBM SPSS 20.0) serve as a crucial tool for analyzing healthcare facilities. The Multivariate technique of factor analysis (MVA) is employed to explore the interconnected dimensions of variables in this study. Analysis entails the creation of tables and maps, facilitating the drawing of conclusions. Utilizing Secondary data collected from Census and Panchayat level Statistics, Palakkad offers a comprehensive insight into healthcare facilities at the block level. Multivariate analysis of variance (MANOVA) within SPSS organizes variables pertaining to healthcare facilities, aiming to discern differences between groups and group variations across multiple dependent variables concurrently. It also helps as a data reduction or structural simplification process, in Sorting and grouping, and prediction of relationships between variables. The assessment extends to healthcare facilities across the 13 blocks of Palakkad district in Kerala. The entire matrix of interrelated variables, structured as 13 x 25, forms the basis for statistical analysis.

Results and Discussion

Health care indicators represent the development of medical care infrastructure in the public and private sectors. Here the public sector is only taken into consideration as it is accessible to everyone alike. In measuring the availability of health care services, the number of health care institutions (hospitals, PHCs etc) is taken in relation to total population.

The indicators are used with respect of population because the facilities of these services to people are main concern, and in some times, area are taken because of accessibility aspects.

Table 1.2, Block-wise details of number of PHCs and Dispensaries per lakh of population in Palakkad-2011

Blocks	No. of PHCs and Dispensaries	No. of PHCs and Dispensaries/lakh of population	Index (1)	Rank
Alathur	5	1.865	0.699	11
Attappady	3	4.664	1.747	1
Chittur	5	2.566	0.961	8
Kollengode	6	4.585	1.717	2
Kuzhalmannam	6	3.436	1.287	5
Malampuzha	6	2.468	0.924	9
Mannarkkad	6	1.875	0.702	10
Nenmara	6	4.339	1.625	3
Ottappalam	7	3.417	1.280	6
Palakkad	6	1.740	0.652	12
Pattambi	6	1.731	0.648	13
Srikrishnapuram	7	3.920	1.468	4
Thrithala	6	2.988	1.119	7
Palakkad total	75	2.670	1	-

Source: Department of Health care, Civil Station, Palakkad.

Table 1.3. Block-wise details of Number of PHCs and Dispensaries (per 100 sq.km area) in Palakkad – 2011

Blocks	No. of PHCs and Dispensaries	No. of PHCs and Dispensaries/100.sq.km of area	Index (2)	Rank
Alathur	5	1.344	0.802	9
Attappady	3	0.425	0.254	13
Chittur	5	1.908	1.139	8
Kollengode	6	3.108	1.586	5
Kuzhalmannam	6	3.667	2.185	1
Malampuzha	6	1.282	0.765	10
Mannarkkad	6	1.240	0.740	11
Nenmara	6	0.774	0.462	12
Ottappalam	7	3.535	2.110	2
Palakkad	6	2.580	1.540	6
Pattambi	6	2.333	1.391	7
Srikrishnapuram	7	3.180	1.899	4
Thrithala	6	3.490	2.083	3
Palakkad total	75	1.675	1	

Source: Department of Health care, Civil Station, Palakkad

Table 1.2 and 1.3 shows the ranking of the blocks on the basis of index of PHCs and dispensaries per lakh of population shows that Attappady block occupy 1st rank with an index of 1.747, due to its low proportion of population, followed by Kollengode and Nenmara with indices of 1.717 and 1.625 respectively. It is significant to note that Pattambi which is one of the densely populated area with highest density of population in the district has lowest ranking identified with an index value of 0.648. When area is considered, Kuzhalmannam comes first with an index of 2.185, owing to wider area; Attappady is on 13th rank with an index of 0.25. In the case of Community Health Centers, population-wise and area-wise distributions are given in the tables below.

Table 1.4 Block-wise details of Number of CHCs per lakh of population in Palakkad – 2011

Blocks	No. of CHCs	No. of CHCs/lakh of population	Index (3)	Rank
Alathur	2	0.746	1.104	7
Attappady	1	1.555	2.300	1
Chittur	2	1.026	1.518	3
Kollengode	1	0.764	1.130	6
Kuzhalmannam	1	0.573	0.848	11
Malampuzha	0	0	0	13
Mannarkkad	1	0.312	0.462	12
Nenmara	1	0.723	1.070	8
Ottappalam	2	0.976	1.444	5
Palakkad	2	0.580	0.858	9
Pattambi	2	0.571	0.853	10
Srikrishnapuram	2	1.120	1.657	2
Thrithala	2	0.996	1.473	4
Palakkad total	19	0.676	1	

Source: Department of Health care, Civil Station, Palakkad

Table 1.4 shows the proportions of CHCs are calculated on the basis population, Attappady block scores highest ranking with index 2.300, due to its smallest contribution of population. Srikrishnapuram gets the second rank and has an index value of 1.657. Mannarkkad has the lowest index value ie. 0.462, and there are no CHCs in Malampuzha block.

Table 1.5 Block-wise details of Number of CHCs (per 100 sq.km) in Palakkad – 2011

Blocks	No. of CHCs	No. of CHCs/ 100 sq.km of area	Index (4)	Rank
Alathur	2	0.535	1.261	8
Attappady	1	0.142	0.335	11
Chittur	2	0.763	1.644	6
Kollengode	1	0.518	1.221	9
Kuzhalmannam	1	0.609	1.436	7
Malampuzha	0	0	0	13
Mannarkkad	1	0.207	0.488	10
Nenmara	1	0.134	0.316	12
Ottappalam	2	1.010	2.381	2
Palakkad	2	0.858	2.024	4
Pattambi	2	0.779	1.837	5
Srikrishnapuram	2	0.909	2.144	3
Thrithala	2	1.163	2.743	1
Palakkad total	19	0.424	1	

Source: Department of Health care, Civil Station, Palakkad

Table 1.5 shows the distribution of CHCs per 100 sq.km area shows that Thrithala, Ottappalam, and Srikrishnapuram are in the first three positions, with indices of 2.743, 2.381 and 2.144 respectively. Blocks such as Mannarkkad, Attappady, and Nenmara show very low level of indices.

Table 1.6. Block-wise details of Number of Allopathic doctors per lakh of population in Palakkad – 2011

Blocks	No. of Allopathic doctors	No. of Allopathic doctors/lakh of population	Index (5)	Rank
Alathur	31	11.563	1.156	7
Attappady	8	12.438	1.244	4
Chittur	23	11.804	1.180	5
Kollengode	12	9.170	0.917	8
Kuzhalmannam	23	13.172	1.317	3
Malampuzha	10	4.113	0.411	11
Mannarkkad	12	3.750	0.375	13
Nenmara	9	6.509	0.650	10
Ottappalam	31	15.130	1.513	2
Palakkad	72	20.880	2.088	1
Pattambi	14	4.040	0.040	12
Srikrishnapuram	21	11.759	1.176	6
Thrithala	15	7.470	0.747	9
Palakkad total	281	11.000	1	

Source: Department of Health care, Civil Station, Palakkad

The proportion of doctors to total population is another indicator for Health care measurement, which is given in the table 1.6.Ranking of blocks on the basis of number of allopathic doctors discloses that 1st rank is for Palakkad block, followed by Ottappalam and Kuzhalmannam with indices 2.088, 1.513 and 1.317 respectively. Mannarkkad accounts for the lowest index which is 0.375. It may be noted that Pattambi taluk which has the highest density of population in the district has only 29 allopathic doctors and Ottapalam which as second highest population density has got 31 doctors whereas Palakkad urban agglomeration has got 72 doctors. Total numbers of Hospital beds per blocks are given below, which includes beds from Govt. hospitals, Taluk hospitals, PHCs, CHCs and dispensaries.

Table 1.7 Block-wise details of total No. of Hospital beds per lakh of population in Palakkad – 2011

Blocks	No. of hospital beds	No. of hospital beds/lakh of population	INDEX (6)	RANK
Alathur	246	91.757	1.156	5
Attappady	100	155.477	1.952	2
Chittur	247	126.769	1.597	3
Kollengode	78	59.605	0.751	7
Kuzhalmannam	98	56.125	0.707	8
Malampuzha	38	15.627	0.197	12
Mannarkkad	66	20.624	0.260	11
Nenmara	10	7.232	0.091	13
Ottappalam	255	124.459	1.568	4
Palakkad	768	222.720	2.806	1
Pattambi	88	25.392	0.320	10
Srikrishnapuram	141	78.954	0.995	6
Thrithala	95	47.303	0.596	9
Palakkad total	2230	79.363	1	

Source: Department of Health care, Civil Station, Palakkad

Table 1.7 shows Palakkad block possesses the first ranking, followed by Attappady and Chittur and their indices are 2.806, 1.952 and 1.597 respectively. Nenmara lags behind all other blocks and the index is 0.091.
Ayurvedic and Homeopathic treatment methods also have importance in social medicine, and their block-wise distributions are given below in the tables 1.8 and table 1.9 gives their area wise distribution

Table 1.8 Block-wise details of number of Ayurvedic and Homeopathic dispensaries per lakh of population in Palakkad – 2011

Blocks	No. of Ayurvedic and Homeopathic Dispensaries	No. of Ayurvedic and Homeopathic Dispensaries/lakh of population	INDEX (7)	RANK
Alathur	9	3.356	0.806	10
Attappady	7	10.80	2.594	1
Chittur	8	4.105	0.989	8
Kollengode	9	6.877	1.651	2
Kuzhalmannam	11	6.30	1.513	4
Malampuzha	12	4.94	1.186	6
Mannarkkad	7	2.187	0.525	13
Nenmara	8	5.786	1.390	5
Ottappalam	14	6.83	1.640	3
Palakkad	8	2.319	0.557	12
Pattambi	9	2.60	0.624	11
Srikrishnapuram	8	4.48	1.075	7
Thrithala	7	3.48	0.836	9
Palakkad total	117	4.164	1.	

Source: Department of Health Care, Civil Station, Palakkad

The table 1.8 shows details of number of Ayurvedic and Homeopathic dispensaries per lakh of population in Palakkad. While 1st rank is occupied by Attappady with an index 2.594. 2nd and 3rd ranks are occupied by Kollengode (1.651) and Ottappalam (1.640). Palakkad and Mannarkkad lag behind all other blocks with indices values of 0.557 and 0.525

Table 1.9 Block-wise details of Number of Ayurvedic and Homeopathic dispensaries (100 sq.km area) in Palakkad – 2011

Blocks	No. of Ayurvedic and Homeopathic dispensaries	No. of Ayurvedic and Homeopathic dispensaries per 100 sq.km	INDEX (8)	RANK
Alathur	9	2.406	0.920	10
Attappady	7	0.992	0.379	13
Chittur	8	3.053	1.168	8
Kollengode	9	4.663	1.783	3
Kuzhalmannam	11	6.707	2.566	2
Malampuzha	12	2.564	0.981	9
Mannarkkad	7	1.446	0.553	11
Nenmara	8	1.074	0.411	12
Ottappalam	14	7.070	2.704	1
Palakkad	8	3.433	1.313	7
Pattambi	9	3.502	1.340	6
Srikrishnapuram	8	3.636	1.505	5
Thrithala	7	4.069	1.557	4
Palakkad total	117	2.614	1	

Source: Department of Health care, Civil Station, Palakkad

The table 1.9 shows that when number of Ayurvedic and Homeopathic dispensaries are taken per 100 sq.km area, first three ranks belongs to Ottappalam, Kuzhalmannam and Kollengode blocks, with indices 2.704, 2.566 and 1.783 respectively. Nenmara and Attappady are in the 12th and 13th ranks.

Table 1.10 Block-wise details of Number of Ayurvedic and Homeopathic doctors per lakh of population in Palakkad – 2011

Blocks	No. of Ayurvedic and Homeopathic doctors	No. of Ayurvedic and Homeopathic doctors/lakh of population	INDEX (9)	RANK
Alathur	9	3.357	0.786	10
Attappady	7	10.883	2.549	1
Chittur	8	4.106	0.962	8
Kollengode	9	6.887	1.611	2
Kuzhalmannam	11	6.30	1.475	4
Malampuzha	12	4.935	1.156	6
Mannarkkad	10	3.125	0.732	11
Nenmara	8	5.786	1.355	5
Ottappalam	14	6.833	1.600	3
Palakkad	8	2.32	0.543	13
Pattambi	9	2.597	0.608	12
Srikrishnapuram	8	4.48	1.049	7
Thrithala	7	3.485	0.816	9
Palakkad total	120	4.270	1	

Source: Department of Health care, Civil Station, Palakkad

As compared to population size, concentration of Ayurvedic and Homeopathic doctors are maximum in Attappady, Kollengode and Ottappalam with corresponding indices of 2.6, 1.6 and1.6, Table 1.10. In the case of none-allopathic doctors, Palakkad has the lowest rank. It is interesting to note that rural areas are more developed in the case of Ayurvedic and Homeopathic doctors, while urban areas are not.

Composite Index of Health Care facilities:
Considering all the above indicators a composite index is made which is given on the table 1.11

Table 1.11. Composite Index of Health care facilities

Blocks	Individual indices									Index	Rank
	1	2	3	4	5	6	7	8	9		
Alathur	0.699	0.802	1.104	1.261	1.156	1.156	0.806	0.920	0.786	0.965	9
Attappady	1.747	0.254	2.300	0.335	1.244	1.952	2.594	0.379	2.549	1.483	2
Chittur	0.961	1.139	1.518	1.644	1.180	1.597	0.989	1.168	0.962	1.240	8
Kollengode	1.717	1.586	1.130	1.221	0.917	0.751	1.651	1.783	1.611	1.374	6
Kuzhalmannam	1.287	2.185	0.848	1.436	1.317	0.707	1.513	2.566	1.475	1.481	3
Malampuzha	0.924	0.765	0	0	0.411	0.197	1.186	0.981	1.156	0.624	12
Mannarkkad	0.702	0.740	0.462	0.488	0.375	0.260	0.525	0.553	0.732	0.537	13
Nenmara	1.625	0.462	1.070	0.316	0.650	0.091	1.390	0.411	1.355	0.819	11
Ottappalam	1.280	2.110	1.444	2.381	1.513	1.568	1.640	2.704	1.600	1.804	1
Palakkad	0.652	1.540	0.858	2.024	2.088	2.806	0.557	1.313	0.543	1.376	5
Pattambi	0.648	1.391	0.853	1.837	0.040	0.320	0.624	1.340	0.608	0.851	10
Srikrishnapuram	1.468	1.899	1.657	2.144	1.176	0.995	1.075	1.505	1.049	1.441	4
Thrithala	1.119	2.083	1.473	2.743	0.747	0.596	0.836	1.557	0.816	1.333	7
Palakkad total	1	1	1	1	1	1	1.	1	1		

Source: Computed from secondary data

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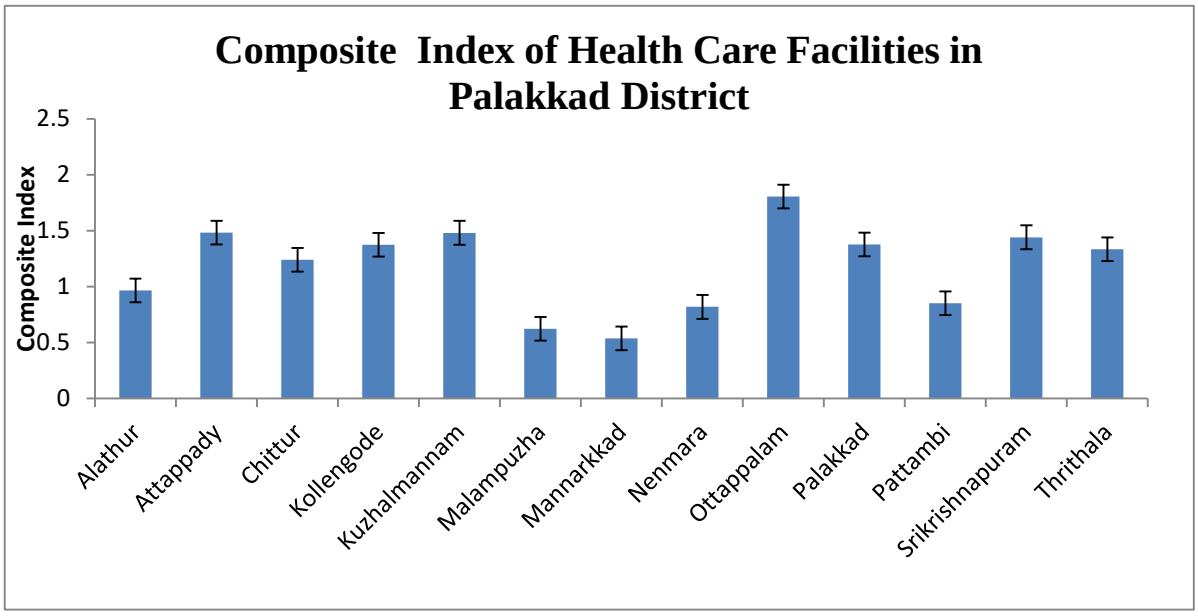

Figure1. 2: Composite index of health care facilities in Palakkad District.

Table 1.11 and figure 1.2 and 1.3 shows the estimated Composite Index of Health Care Facilities (CIHCF) shows the fact, that Ottappalam block tops in the list with an index value of 1.804. It is interesting to note that Attappady possesses the 2nd position with an index value of 1.483 due to its low population level. The third position is occupied by Kuzhalmannam block having an index value of 1.481. In addition to these three blocks, Chittur, Kollengode, Kuzhalmannam, Palakkad, Srikrishnapuram and Thrithala have the index value above 1. Nenmara, Malampuzha, and Mannarkkad are characterized by least value for index, 0.819, 0.624 and 0.537 respectively.

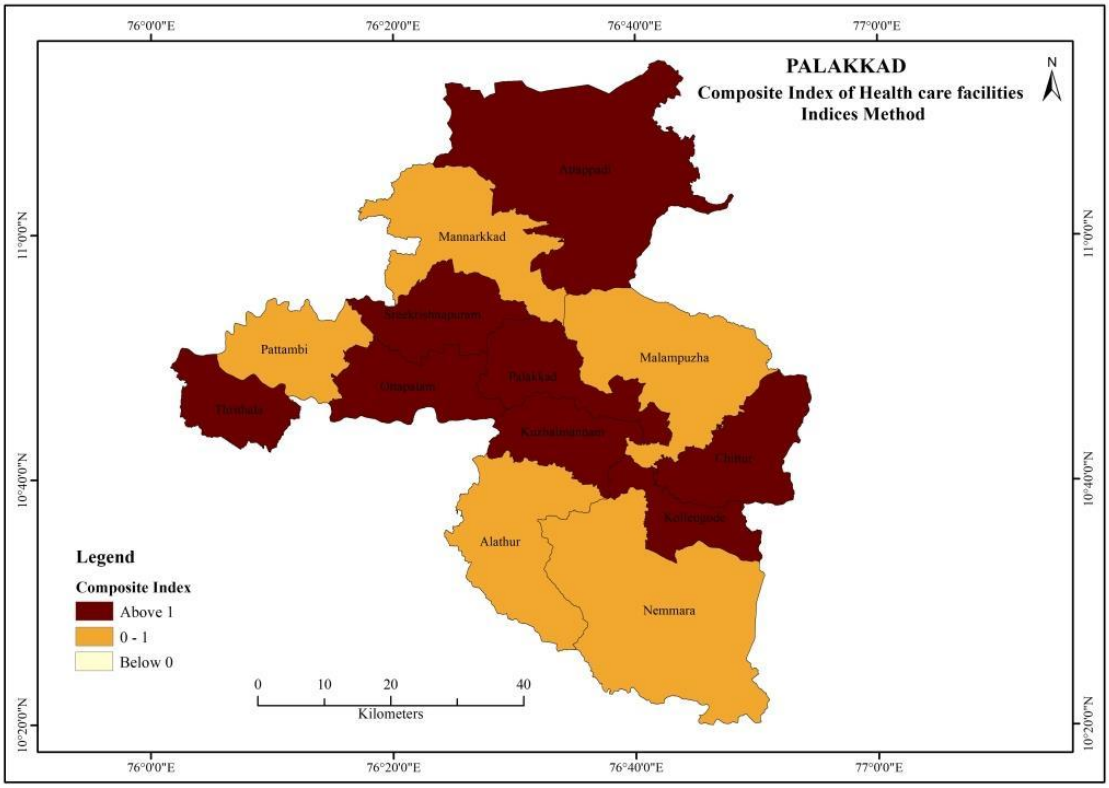

Figure 1.3: Composite index of health care facilities indices method in Palakkad District

Health care, like many public services, is not equally available to all individuals. This is because it is not a 'pure' public good (Cox and Reynolds 1974). One of the major reasons for public services being impure is geographical in nature. Demand for public services emanates from individuals, who, in aggregate, are continuously (though unevenly) dispersed across space, while most public services are distributed from discrete facilities with fixed locations

Multivariate analysis of the health care disparity

The present study aims to analyze the spatial distribution of health care disparity. The available heath care facilities and the demographic characteristics of the general population of the study area. On the basis of the health care facility there are 25 variables selected in the statistical analysis. The extraction of table 1.12 illustrate the total variance explained by the variables included in the analysis. The distribution of eigen values and the total percentage and cumulative percentage variance of each one of the factor solution is presented in the Table 1.12. It is pertinent to note that five factors with 1.98 rotated eigen vector values explains 97.5 % of the variance in the data set. The Eigen value 1.40 is considered as a yardstick to extract 5 factors and the same are resolved owing to the fact that almost all the variables got loaded with these factors. The 5 factors explain altogether 97.55 %of the total variance are shown in the table (vide table 1.12).

Table :1.12 Major Factors and Total Variance Explained

Total Variance Explained									
Component	Initial Eigen values	Extraction Sums of Squared Loadings					Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.584146	30.336	30.336	7.584	30.336	30.33658	6.88	27.520	27.520
2	6.284433	25.137	55.474	6.284	25.137	55.47431	6.271	25.082	52.602
3	6.173738	24.694	80.169	6.173	24.694	80.16927	5.13	20.526	73.129
4	2.944234	11.776	91.946	2.944	11.776	91.9462	4.11	16.469	89.599
5	1.402991	5.6119	97.558	1.402	5.6119	97.558	1.98	7.9589	97.558

Major Factors and their Variable Loadings:

The first component which explains 27.52 % of the total variance is significantly loaded with 7 variables (see table 1.13). The factor loading positive values of 7 variables lies between (0.99 to 0.95) in both the directions. The variables with positive loadings cluster include No. of Homeopathic dispensaries (0.997), No. of Ayurvedic Dispensaries (0.997) No. of PHCs and Dispensaries (0.997) No. of Homeopathic doctors (0.996) No. of CHCs (0.992) No. of Allopathic doctors (0.977) No. of hospital beds (0.951).

Table-1.13 Variables in the component 1, Homeopathic, Ayurvedhic and Allopathic health care

Sl no	Variables	Component
1	No. of Homeopathic dispensaries	0.997
2	No. of Ayurvedic Dispensaries	0.997
3	No. of PHCs and Dispensaries	0.997
4	No. of Homeopathic doctors	0.996
5	No. of CHCs	0.992
6	No. of Allopathic doctors	0.977
7	No. of hospital beds	0.951

Source ::Extraction Method: Principal Component Analysis. Rotated Component Matrix

Therefore this component is rightly called as Homeopathic ,Ayurvedhic and Allopathic health care

Table 1.14 shows the second component which accounts for 25.082 % of the total variance includes 7 variables with strong loading values between 0.975 and 0. 50 in both the directions. No. of Ayurvedic Dispensaries/lakh of population ,0.975, Index No. of Ayurvedic dispensaries /lakh of population0.975, No. of Homeopathic doctors/lakh of population0.973, Index of phc0.909, No. of PHCs and Dispensaries/lakh of population0.909, No. of CHCs/lakh of population0.501, Index of CHC/population0.500. In total (8) variables are included under this dimension explained the characteristic of the general population and the association of the allopathic, Ayurvedhic and homeopathic available

medical facilities and population. Hence this component is named as **Dimension of Service ratio and Health Care Accessibility.**

Table 1.14 Variables II Service ratio and Health Care Accessibility.

Sl no	Variables	Components
1	No. of Ayurvedic Dispensaries/lakh of population	0.975
2	Index No. of Ayurvedic Dispensaries/lakh of population	0.975
3	No. of Homeopathic doctors/ lakh of population	0.973
4	Index No. of Homeopathic doctors/lakh of population	0.973
5	Index of PHC	0.909
6	No. of PHCs and Dispensaries/lakh of population	0.909
7	No. of CHCs/lakh of population	0.501
8	Index of CHC/population	0.500

Source ::Extraction Method: Principal Component Analysis. Rotated Component Matrix

Table 1.15 shows Third component explains (20.5%) the total variance with 6 variable factors. The positive variable expressed as No. of PHCs and Dispensaries/100.sq.km of area0.98, index of No. of PHCs and Dispensaries/100.sq.km of area0.978, Index No. of Homeopathic dispensaries per 100 sq.km0.959885 No. of Homeopathic dispensaries per 100 sq.km0.954079, Index No. of CHCs/ 100 sq.km of area0.768241, No. of CHCs/ 100 sq.km of area0.759. Hence this component is named as Dimension proximity of health centers role in the health care

Table 1.15 Component III proximity of health centers role in the health care

Sl no	Variable	Components
1	No. of PHCs and Dispensaries/100.sq.km of area	0.980
2	index of No. of PHCs and Dispensaries/100.sq.km of area	0.978
3	Index No. of Homeopathic dispensaries per 100 sq.km	0.959
4	No. of Homeopathic dispensaries per 100 sq.km	0.954
5	Index No. of CHCs/ 100 sq.km of area	0.768
6	No. of CHCs/ 100 sq.km of area	0.759

Source :Extraction Method: Principal Component Analysis. Rotated Component Matrix

Table 1.16 shows that Fourth component explains (16.4%) the total variance with 4 variable factors. No. of Homeopathic doctors/lakh of population0.973, Index No. of Homeopathic doctors/lakh of population0.973, Index of phc0.909 No. of PHCs and Dispensaries/lakh of population0.909 No. of CHCs/lakh of population0.501 Index of CHC/population0.500. This component is conveniently stated as living status of **Availability of Allopathic health care personals role in health care**

Table 1.16 Variables IV proximity of health centers role in the health care

Sl no	Variable	Components
1	Index allopathic No. of hospital beds/lakh of population	0.972
2	No. of hospital beds/lakh of population	0.972
3	No. of Allopathic doctors/lakh of population	0.924
4	Index No. of Allopathic doctors/lakh of population	0.912

Source ::Extraction Method: Principal Component Analysis. Rotated Component Matrix

Table 1.17 shows Fifth component account for only 7.95% of the total variance and loaded with 4variables in the dimension of community health care in Palakkad district. Index of CHC/population0.789, No. of CHCs/lakh of population0.788, No. of CHCs/ 100 sq.km of area0.501, Index No. of CHCs/ 100 sq.km of area0.493 .As this component explain the multidimensional determinant factors of the accessibility and availability treatment along with the social problems here this dimension is named as **Dimension of Accessibility and Availability of CHC in the Society.**

Table 1.17 Variables related Accessibility and Availability of CHC in the Society.

Sl no	Variables	Loadings (%)
1	Index of CHC /population	0.789
2	No. of CHCs/lakh of population	0.788
3	No. of CHCs/ 100 sq.km of area	0.501
4	Index No. of CHCs/ 100 sq.km of area	0.493

Source ::Extraction Method: Principal Component Analysis. Rotated Component Matrix

Table 1.18 Palakkad : Block wise distribution of the five Factors and their Composite Index

BLOCKS	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Composite score
Alathur	-0.319	-0.876	-0.704	0.496	0.089	-1.31
Attappady	-0.343	2.144	-1.659	0.994	0.876	2.01
Chittur	-0.308	-0.486	-0.286	0.620	0.807	0.34
Kollengode	-0.207	1.142	0.702	-0.477	-0.356	0.80
Kuzhalmannam	-0.172	0.774	1.526	0.018	-1.386	0.75
Malampuzha	-0.355	-0.046	-0.674	-0.776	-2.102	-3.95
Mannarkkad	-0.418	-1.015	-0.989	-0.839	-0.600	-3.86
Nenmara	-0.309	0.647	-1.130	-0.973	0.096	-1.66
Ottappalam	-0.054	0.770	1.607	0.719	-0.203	2.83
Palakkad	-0.218	-1.372	0.015	2.506	-0.543	0.38
Pattambi	-0.303	-1.118	0.196	-1.163	0.451	-1.93
Srikrishnapuram	-0.200	0.073	0.669	-0.182	1.301	1.66
Thrithala	-0.253	-0.554	1.000	-0.842	1.583	0.93

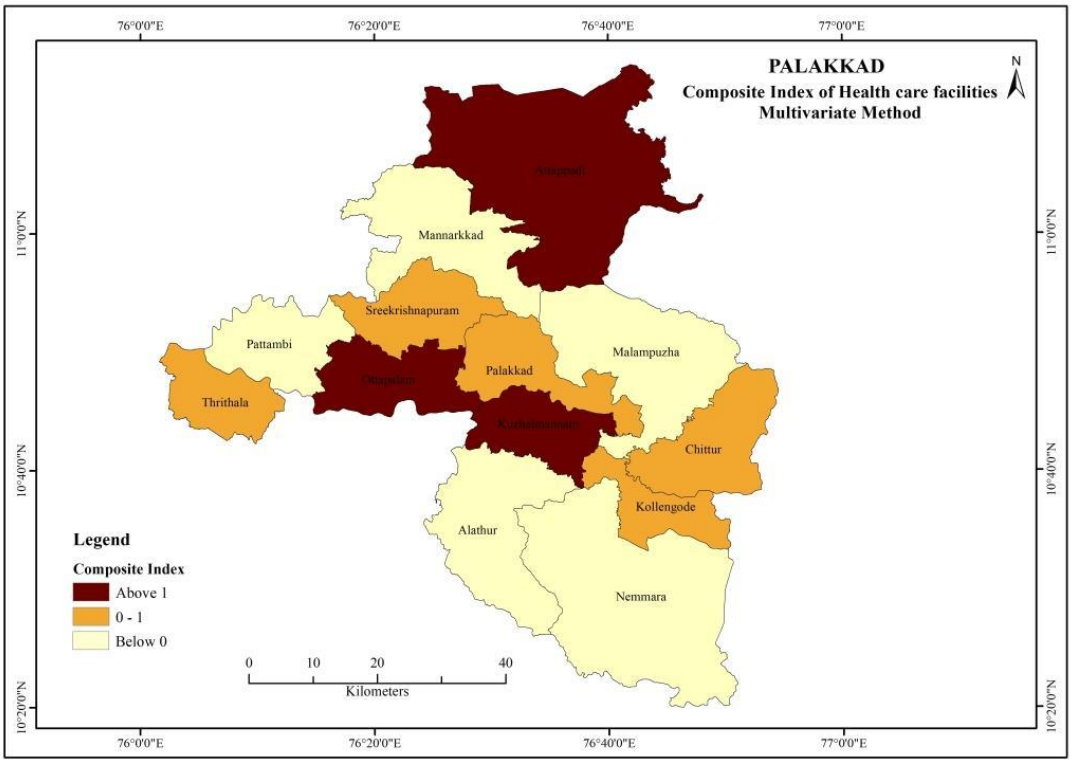

Figure. 1.4 Composite Index: Composite Index of Health care Multivariate method

Table 1.18 and figure 1.4 shows Blocks with High Health care Facility/ development recorded in Ottapalam and Attapadi blocks. While Blocks with medium Health care development noticed in Sreekrishnapuram, Thrithala, Kollengode, Kuzhalmannam,Palakkad and Chittur Blocks with low Health care development identified in Alathur, Nenmara, Patambi, Mannarkkad,and Malampuzha blocks.

Ten factors are explained separately on the basis of the relative importance to their score values obtained for health care disparity and associated problems. However, it will not give an entire image about the spatial pattern of complexity of the problems in the study area. Hence, the overall variable factors related to health care explained through the 5 factors taken in to consideration to consolidate the disparity in fourteen blocks in palakkad. The sum of factor scores/ composite factor score index with a value > +2 in positive direction denotes very high health care facility. The values between 0 to 2 indicates medium health care facility, while the value of below zero stands for low health care facility. The composite score thus obtained has been illustrated through a Geographic Information System based map to visualize the spatial variation of health care disparity and to integrate the factors associated with regional variation in order to highlight macro level planning proposal. Accordingly, under both methods, similar blocks are noted as high and low categories within the total 13 blocks of the Palakkad district of Kerala state, 2 block represent high/positive composite index followed by 6 blocks with medium composite index, 5 blocks with low/ negative composite index.

Practical Implications and Way forward

Based on findings, this research suggests an urgent need for efforts by the government to develop health care facilities in Malampuzha, Mannarkkad and Pattambi. This analysis has paved light to some questions, they are aptly stated as follows

i. Is it a matter of deliberate decision, or preference to allocate a greater number of Ayurvedic and Homeopathic dispensaries in rural areas such as Attapady and Kollengode .
ii. Why do Palakkad, an urban agglomeration with such high population significantly lack Ayurvedic and homeopathic facilities?. There is a clear cut rural urban divide noticed in the allocation of CHCs and PHCs doctors etc. Is it based on socio economic status or preferences of the inhabitants or merely based on political will? Urban areas have a greater number of allopathic hospitals facilities including doctors than ayurvedic and homeopathic.
iii. Allocation of community health centers are not equally distributed spatially or proportional to the needs, as there are no CHCs in Malampuzha block.
iv. Why there are significant shortage of health care facilities in blocks that are densely populated such as Pattambi, Nenmara, Mannarkkad and Malampuzha ?

It shows the need to have there must be a need-based development. It must depend up on the multidimensional aspects, that reflects characteristics of health status, their behaviors and the environments in which they live. In health care sector, the district has a wider scope for improvement. In Palakkad, there are 2,133,000 people living in rural areas and 676000 people living in urban areas. 59% of the women are anemic and 18.6% of the children have stunted growth rate. Hence, there is a need to have priority based developmental schemes. Focus has to be withdrawn from areas that have over saturated with facilities and developmental schemes to the areas that really lack them.

GIS has been used for many years to link diverse layers of population and environmental information to characterize the many dimensions of health care need for small and large areas. In recent times, R Studios and ecosystem are widely used as an influential platform to perform both statistical and spatial analysis. The spatial variation people living with and health care facility is in complex nature to the pattern of multidimensional character and identify the specific strategy for planning health services. Hence a composite multi score is computed and GIS Maps are being used to explore the problem area identification. Suraj Jacob(2014) has attributed the lessening gaps in regional disparities in health care to modern Kerala's welfare policy regime, which emphasized greater growth of infrastructure facilities in weaker areas.

Conclusion

This assessment may be instrumental in drawing attention to providing the areas that are lacking in health care facilities in the study area. Research on health inequalities has a special significance for policy amendments. As a limitation to the study, it can be noticed that this analysis has taken care of the variables related to health care facilities for physical wellbeing particularly. However, human wellbeing is a factor of positive mental wellbeing, healthy environment and socio-economic status etc. More focused schemes and projects in this line would improve the health care sector in the district. The data used for the analysis is based on 2011 census, hence a revised assessment using the latest census data when it is published would provide a clearer picture of the current status of facilities or lack of it. Quantitative methodologies, such as advanced statistical modeling and Geographic Information Systems (GIS) have evolved to a level of greater sophistication and nuance. This enhanced capability positions us far more effectively than in previous times to play a substantial role in healthcare surveillance, trend monitoring, and the early detection of potential epidemics. Moreover, we can now identify potential risk factors with increased precision. Additionally, our analytical tools enable us to consider and incorporate theoretical frameworks that hold the most promise in the current landscape of public health geographies. The analysis and planning of health services are rooted in the geographic variation of populations and their healthcare needs. These disparities impact the demand for healthcare, the accessibility of healthcare services, and the types of services individuals are willing and able to access. The utilization of Geographic

Information Systems (GIS) is becoming more prevalent in mapping and exploring geographical variations in healthcare needs. GIS is instrumental in developing innovative indicators that accurately reflect the diverse healthcare needs within different geographic areas. The primary goal of the SDG agenda is to ensure healthy lives and promote well-being for everyone, is reiterated in the health-related targets, which are highlighted under SDG 3. In light of this, Equitable health coverage may help achieve the state level SDGs by resulting in fair and long-lasting health outcomes for the inhabitants.

Conflict of Interest
Authors Declare no conflict of Interests.

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