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(RESEARCH ARTICLE)

Age-wise travel patterns and utilization of primary health Centres in Eastern West Khasi Hills District, Meghalaya: A GIS-Based Analysis

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Abstract

Primary Health Centres (PHCs) play a crucial role in providing essential healthcare services to rural populations; however, their effective utilization is strongly influenced by geographical accessibility, travel behaviour, and demographic characteristics. The present study examines age-wise travel patterns and utilization of selected Primary Health Centres in Eastern West Khasi Hills district of Meghalaya using a Geographic Information System (GIS)-based approach. Primary data were collected through a structured questionnaire survey among 100 patients from five selected PHCs—Markasa, Nongthliew, Myriaw, Dongki-ing-ding, and Laitdom—with 20 respondents selected from each PHC using stratified sampling. Information related to age, travel distance, travel time, mode of transportation, frequency of PHC visits, and healthcare services utilized was analysed. GIS techniques, including buffer and overlay analysis, were applied to examine spatial variations in healthcare accessibility and travel patterns among different age groups. Utilization analysis indicates that productive-age groups constitute the major users of PHC services, with general treatment, maternal and child healthcare, immunization, and follow-up care being the most frequently accessed services. The study highlights that healthcare utilization is determined not only by physical distance but also by transportation conditions, service availability, accessibility, and community dependence on healthcare facilities. The findings emphasize the importance of integrating age-specific mobility patterns and spatial accessibility considerations into rural healthcare planning to improve equitable access to primary healthcare services in geographically challenging regions.

Keywords: Healthcare Accessibility; Age-wise Travel Pattern; Healthcare Utilization; Geographic Information System (GIS); Spatial Analysis; Rural Healthcare

1. Introduction

Primary healthcare (PHC) is widely recognized as the cornerstone of an effective, equitable, and sustainable health system[1,2,3]. The Declaration of Alma-Ata emphasized that primary healthcare should be universally accessible, scientifically sound, socially acceptable, and affordable to all individuals and communities [4,5]. This commitment was reaffirmed in the Declaration of Astana, which identified PHC as the foundation for achieving Universal Health Coverage (UHC) and the health-related Sustainable Development Goals [6,7]. In India, Primary Health Centres (PHCs) constitute the first level of contact between rural populations and the public healthcare system, providing comprehensive preventive, primitive, curative, and rehabilitative services under the National Health Mission [8,9,10].Healthcare utilization is influenced not only by the availability of health facilities but also by their accessibility([11,12,13]). Conceptualized healthcare access as the degree of fit between healthcare services and users through five dimensions:

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availability, accessibility, affordability, accommodation, and acceptability [14,15,16]. Among these, geographical accessibility is particularly important in rural areas, where travel distance, travel time, transport availability, and terrain significantly affect healthcare utilization. [17,18,19]. Further emphasized that spatial accessibility reflects the geographical relationship between healthcare facilities and the populations they serve, making it a key determinant of equitable healthcare delivery[20,21,22].A growing body of literature has demonstrated that travel behaviour plays a significant role in healthcare utilization.(23,24,25). Individuals residing farther from healthcare facilities are generally less likely to seek timely medical care because increased travel distance and travel time create physical and economic barriers [26,27,28]. Using Geographic Information System (GIS)-based accessibility measures, reported that road networks, topography, and settlement patterns substantially influence healthcare utilization in rural areas[29,30,31]. Similarly, rural populations experience greater travel burdens than urban populations, leading to disparities in the utilization of primary healthcare services[32,33,34]. These findings suggest that healthcare accessibility should be assessed using actual travel conditions rather than straight-line distance alone(35,36).

Healthcare utilization also varies according to demographic characteristics, particularly age. Children and older adults generally require more frequent healthcare services than younger adults, yet they often experience greater mobility constraints because they depend on caregivers or family members for transportation [37,38,39]. Consequently, age-related differences in mobility contribute to variations in travel patterns and healthcare utilization, especially in rural settings where transportation infrastructure is limited[40,41,42]. In India, despite substantial expansion of the rural healthcare network through the National Health Mission, accessibility to PHCs remains uneven across geographically disadvantaged regions[43,44,45]. Hilly and tribal areas continue to experience limited transportation facilities, dispersed settlements, and poor road connectivity, all of which reduce effective access to healthcare services [46,47,48]. Previous studies have primarily focused on healthcare infrastructure, service availability, and utilization patterns at national or state levels, whereas relatively few have examined how travel characteristics differ across age groups in remote rural settings[49,50,51]. Moreover, studies integrating travel distance, travel time, mode of transport, frequency of PHC visits, and age-wise healthcare utilization remain limited, particularly in Northeast India [52,53,54].

The Eastern West Khasi Hills district of Meghalaya presents a unique geographical setting characterized by rugged terrain, scattered villages, and varying levels of road connectivity[55,56,57]. These physical characteristics are likely to influence how different age groups access and utilize Primary Health Centres[58,59]. However, empirical evidence on age-wise travel patterns and PHC utilization in this region remains scarce . Understanding these patterns is important for identifying spatial inequalities in healthcare access and for improving the planning and delivery of rural healthcare eservices [60,61,62].Therefore, the present study aims to examine the age-wise travel patterns and utilization of selected Primary Health Centres in the Eastern West Khasi Hills district of Meghalaya. Specifically, the study analyses travel distance, travel time, mode of transportation, frequency of PHC visits, and reasons for healthcare utilization across different age groups. The findings are expected to provide evidence for strengthening rural healthcare planning, improving accessibility, and promoting equitable utilization of primary healthcare services in geographically challenging regions.

Objective

To analyse age-wise travel patterns and utilization of Primary Health Centres (PHCs) in Eastern West Khasi Hills district, Meghalaya.

1.1. Study area

Eastern West Khasi Hills, established in 2021, is a centrally located district of Meghalaya with Mairang as its headquarters. Covering 1,145 km^2, the district is characterised by rugged hills, valleys, and dispersed rural settlements that significantly influence accessibility, infrastructure, and service delivery (Figure 1).

It experiences a moderate subtropical highland climate with heavy monsoon rainfall, while its lateritic and red loamy soils support agriculture. The district is drained by numerous rivers belonging to the Brahmaputra and Surma–Meghna basins and forms part of the geologically significant Shillong Plateau. The district has a population of about 131,451, predominantly belonging to the Khasi tribe, with agriculture serving as the main source of livelihood. Road transport is the primary means of connectivity, although difficult terrain and seasonal road conditions limit access to remote villages. The Khasi community's matrilineal social system, traditional culture, and strong community institutions shape the district's socio-economic characteristics. Overall, the district's physical, demographic, and socio-economic features make it a suitable study area for analysing accessibility, travel behaviour, and healthcare utilization.

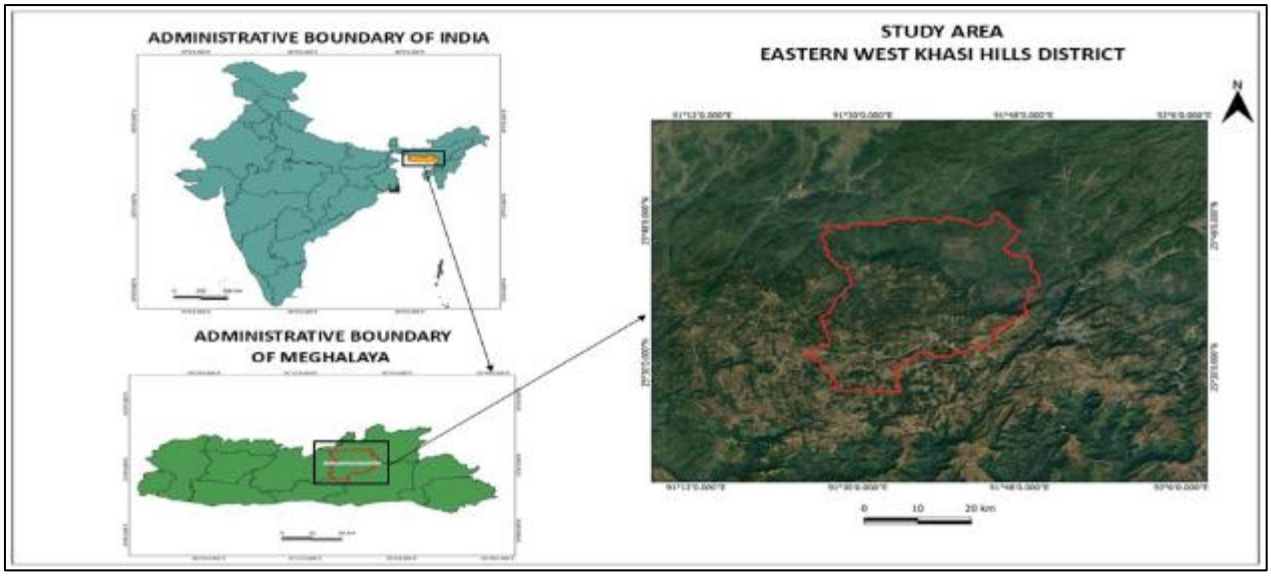

Figure 1 Location of Study Area

2. Methodology

2.1. Data Sources

The study used both primary and secondary data.

- ***Primary data*** were collected through a structured questionnaire survey conducted among **100 patients** from five selected PHCs—Markasa, Nongthliew, Myriaw, Dongki-ing-ding, and Laitdom PHCs. Twenty respondents were selected from each PHC using stratified sampling to ensure representation of different age groups. Information on age, travel distance, travel time, mode of transport, frequency of PHC visits, and place of residence was collected. GPS coordinates of the PHCs were recorded during fieldwork.
- ***Secondary data*** included village distance records obtained from the respective PHCs, district demographic information from the Meghalaya Statistical Handbook (2024), administrative boundary shapefiles from the Survey of India, and Digital Elevation Model (DEM) data from OpenTopography.

2.2. Method of Analysis

Travel pattern analysis was carried out using Geographic Information System (GIS) techniques.

- Mean travel distance was calculated for each age group.
- Buffer zones were generated around each PHC based on the average travel distance of different age groups.
- Buffer layers were overlaid with village and PHC locations to examine spatial variations in travel behaviour and healthcare utilization.
- Maps were prepared using ArcGIS/QGIS to illustrate travel patterns and accessibility.

3. Results and Discussion

3.1. Spatial Distribution of Selected Primary Health Centres and Accessibility Context

The study analysed five selected Primary Health Centres (PHCs), three-dimensional elevation model (Figure 2a) illustrates that the selected PHCs are spatially dispersed across varying topographic environments namely Markasa, Nongthliew, Myriaw, Dongki-ing-ding, and Laitdom, located in the Mairang and Mawthadraishan C&RD Blocks of Eastern West Khasi Hills District. These PHCs represent diverse geographical settings and serve rural populations distributed across varying terrain conditions. The spatial analysis reveals that the selected PHCs are located across different elevation zones, with Markasa, Myriaw, Laitdom, and Nongthliew situated in moderate to high elevation areas, while Dongki-ing-ding occupies a comparatively lower elevation region.The variation in physiographic conditions has important implications for healthcare accessibility. In mountainous and dispersed rural environments, elevation, road

connectivity, and settlement distribution influence travel behaviour and healthcare-seeking patterns. The spatial distribution of the selected PHCs therefore provides an appropriate basis for examining variations in travel distance, accessibility, and utilization among different age (Figure 2b).

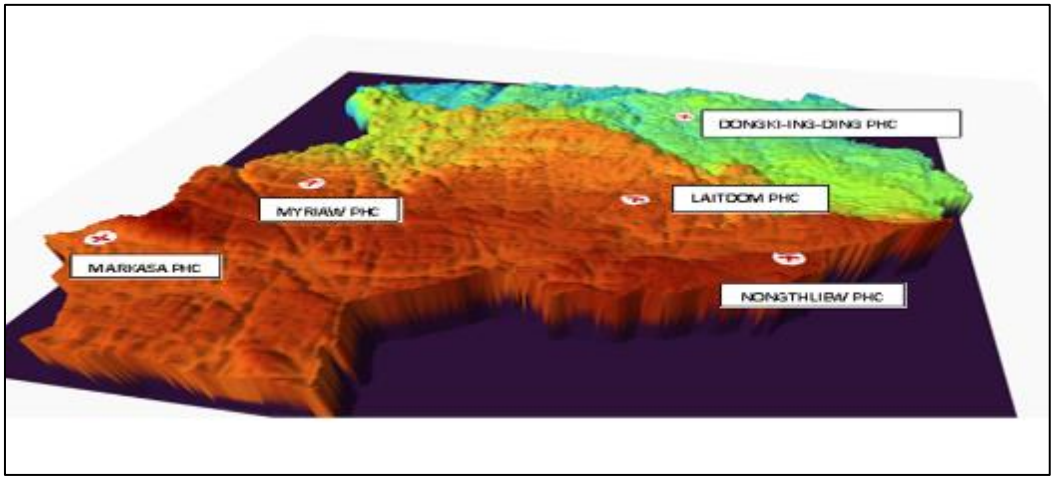

Figure 2 (a) 3D Model of the Location of PHCs in Eastern West Khasi Hills District

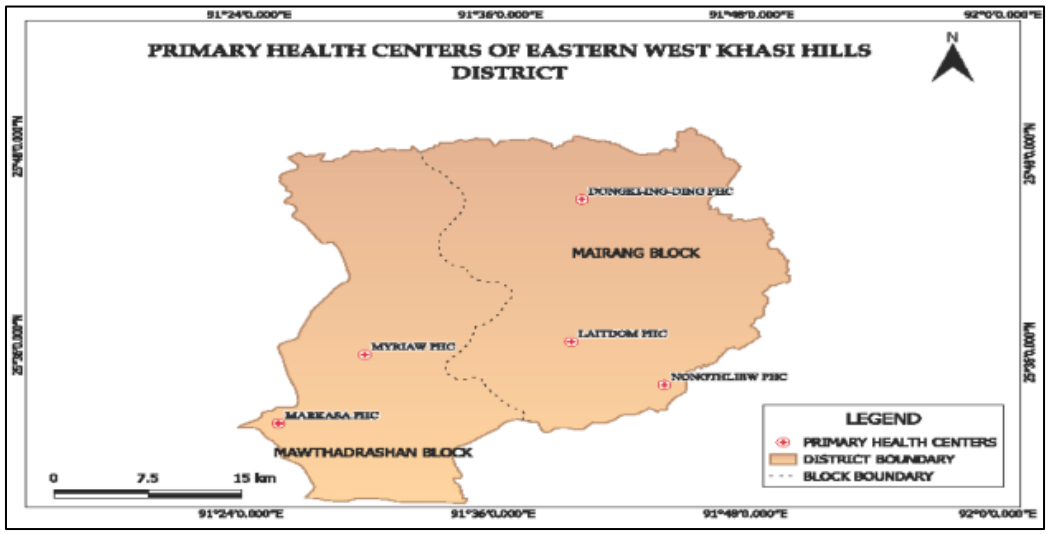

Figure 2 (b) Location of Primary Health Centers in Eastern West Khasi Hills District

3.2. Age-wise Travel Pattern to Primary Health Centres

The analysis of age-wise travel patterns demonstrates significant differences in healthcare mobility among respondents. The mean travel distance varies considerably across age groups, indicating that age-related mobility, dependency, and healthcare requirements influence access behaviour.The highest mean travel distance was recorded among respondents aged 46–60 years (7.57 km), followed by the 31–45 years age group (7.04 km). Respondents aged 15–30 years travelled an average distance of 6.80 km, whereas children below 15 years and elderly respondents above 60 years recorded shorter mean travel distances of 5.60 km and 5.51 km, respectively (Table 1).

Table 1 Age-wise travel patterns to different PHCs

Sl. No.	Block Name	Name Of PHC	<15		15-30		31-45		46-60		>60	
			Total Distance		Total Distance		Total Distance		Total Distance		Total Distance	
			Km	%	Km	%	Km	%	Km	%	Km	%
1	Mairang	Myriaw	15.28	15.27	42.8	24.18	16.7	8.79	18.43	18.72	20.3	23.03
		MARKASA	18.9	18.88	22.67	12.81	17.56	9.24	15.13	15.37	31.07	35.25
2	Mawthadraishan	Nongthliew	32.5	13.47	40.08	22.64	32.7	17.20	8.92	9.06	22.88	25.96
		LAITDOM	14.5	14.49	19.12	10.80	62.67	32.97	39.07	39.68	7.6	8.62
		DONGKI-ING-DING	18.9	18.88	52.33	29.56	60.45	31.80	16.92	17.18	6.3	7.15
		Grand Total	100.8	100 %	177	100 %	190.08	100 %	98.47	100 %	88.15	100 %
		Mean ($\bar{X}$)	5.6		6.80		7.04		7.57		5.51	

The greater travel distances among the 31–45 years and 46–60 years age groups indicate higher mobility among economically active populations. These groups are more capable of travelling longer distances due to greater independence, household responsibilities, and increased healthcare awareness. They may also travel farther when a preferred PHC provides better services or has greater community acceptance.In contrast, children and elderly respondents exhibit relatively localized travel patterns. Children depend largely on caregivers, who generally prefer nearby healthcare facilities to reduce travel costs and physical difficulties. Similarly, elderly populations tend to access closer healthcare centres due to mobility limitations and dependence on family members for transportation.The distance-line analysis further indicates that PHC utilization extends beyond immediate surrounding settlements. Some facilities, particularly Nongthliew and Dongki-ing-ding, serve wider geographical areas due to dispersed settlements and limited alternative healthcare options. This suggests that healthcare utilization is influenced not only by physical distance but also by service availability, accessibility, and community preference.

3.3. Buffer and Overlay Analysis of Healthcare Accessibility

The buffer analysis highlights variations in accessibility among different age groups. The average travel distances of each age category were used to identify areas experiencing relatively better or poorer accessibility.

For respondents below 15 years (Figure 3), Myriaw and Laitdom PHCs demonstrated comparatively better accessibility, whereas Markasa, Nongthliew, and Dongki-ing-ding showed greater travel requirements. Among young adults aged 15–30 years, (Figure 4) Markasa and Laitdom exhibited lower travel burdens, while Myriaw, Nongthliew, and Dongki-ing-ding had wider catchment areas.The 31–45 years and 46–60 years age groups showed the widest travel ranges, reflecting greater mobility and willingness to travel for healthcare services (Figure 5 & Figure 6). Myriaw, Markasa, and Nongthliew PHCs generally provided better accessibility for these groups, whereas Laitdom and Dongki-ing-ding attracted patients from more distant settlements.Among elderly respondents, Laitdom, Nongthliew, and Dongki-ing-ding showed comparatively favourable accessibility, while Myriaw and Markasa recorded longer travel distances.Respondents above 60 years recorded shorter mean travel distances of 5.60 km and 5.51 km, respectively (Figure 7) this indicates that elderly populations are more dependent on nearby healthcare facilities and may experience greater challenges where travel distances increase.

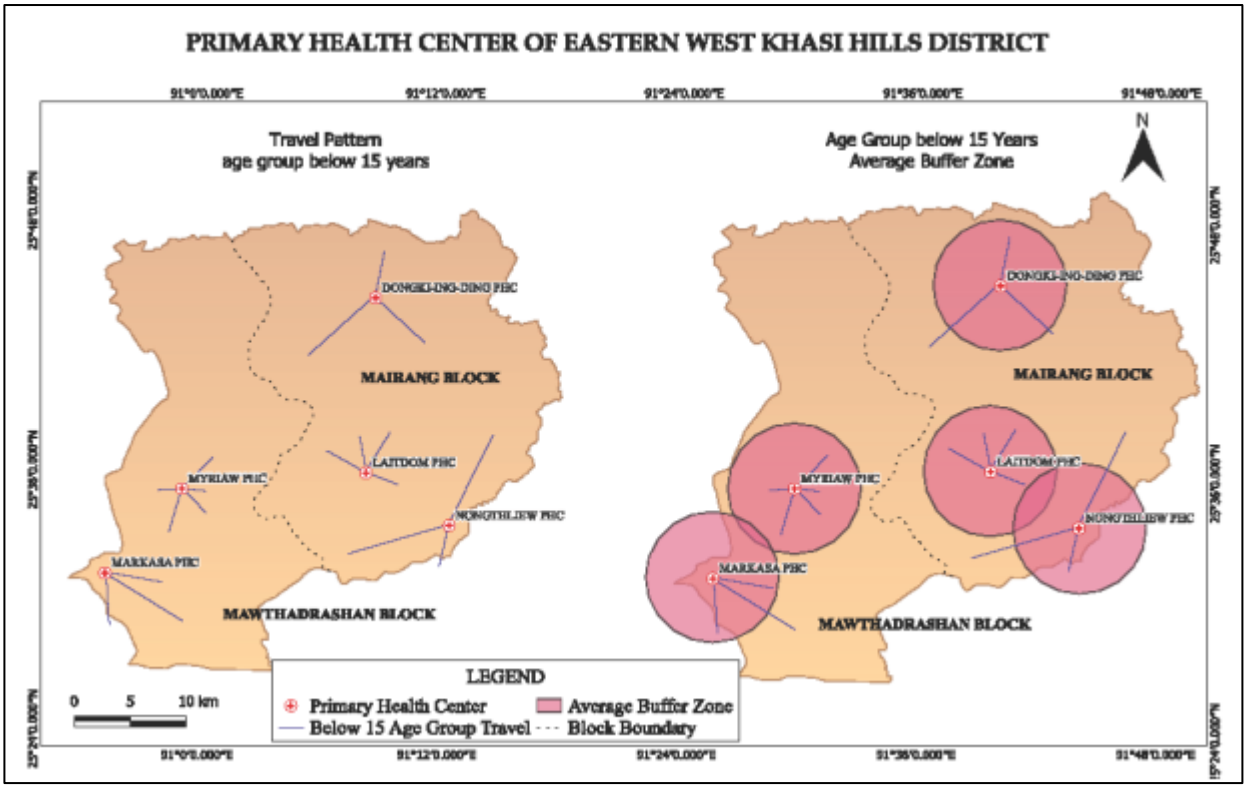

Figure 3 Travel patterns of the below 15 Age Group

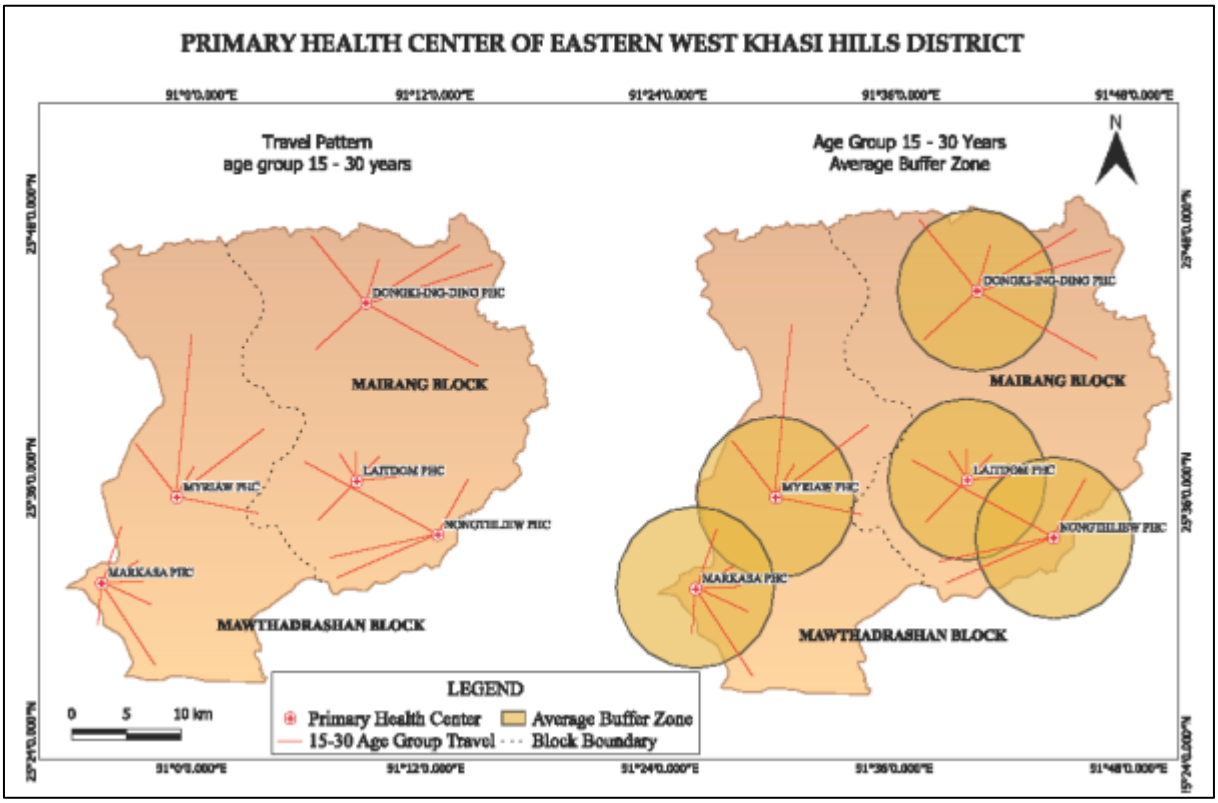

Figure 4 Travel patterns of the 15-30 Age Group

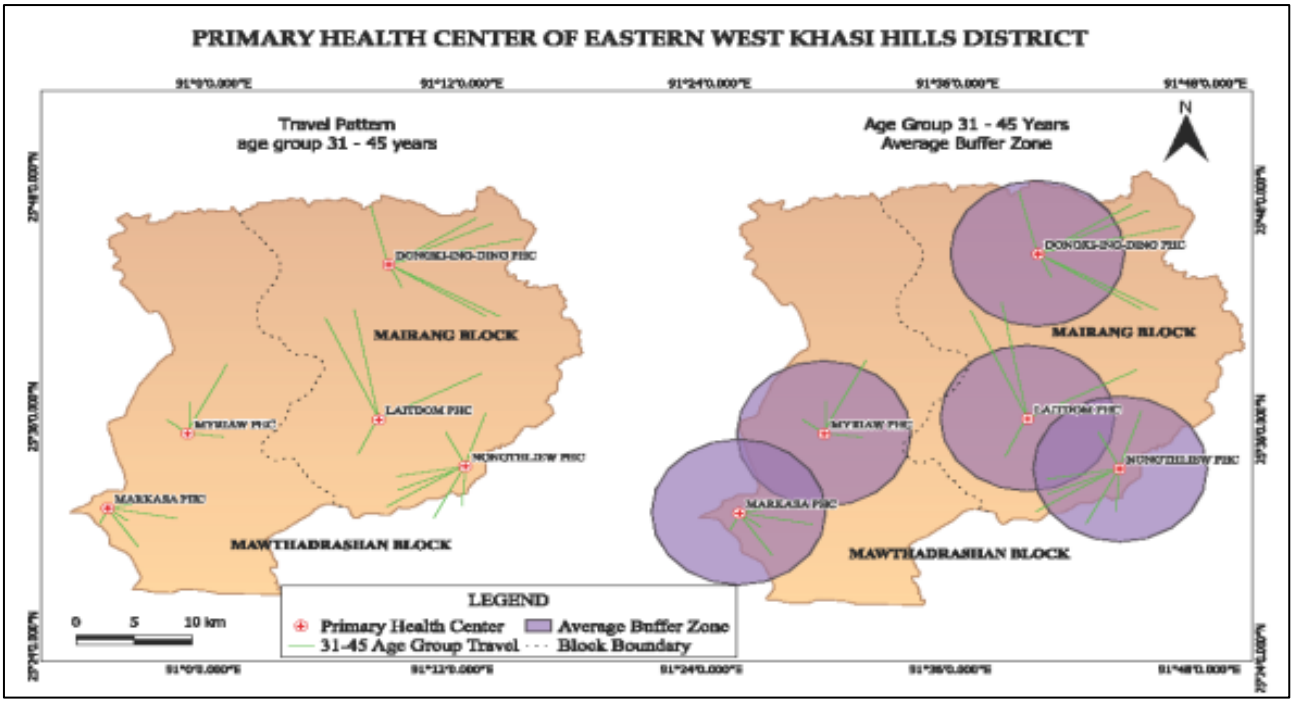

Figure 5 Travel patterns of the 31-45 Age Group

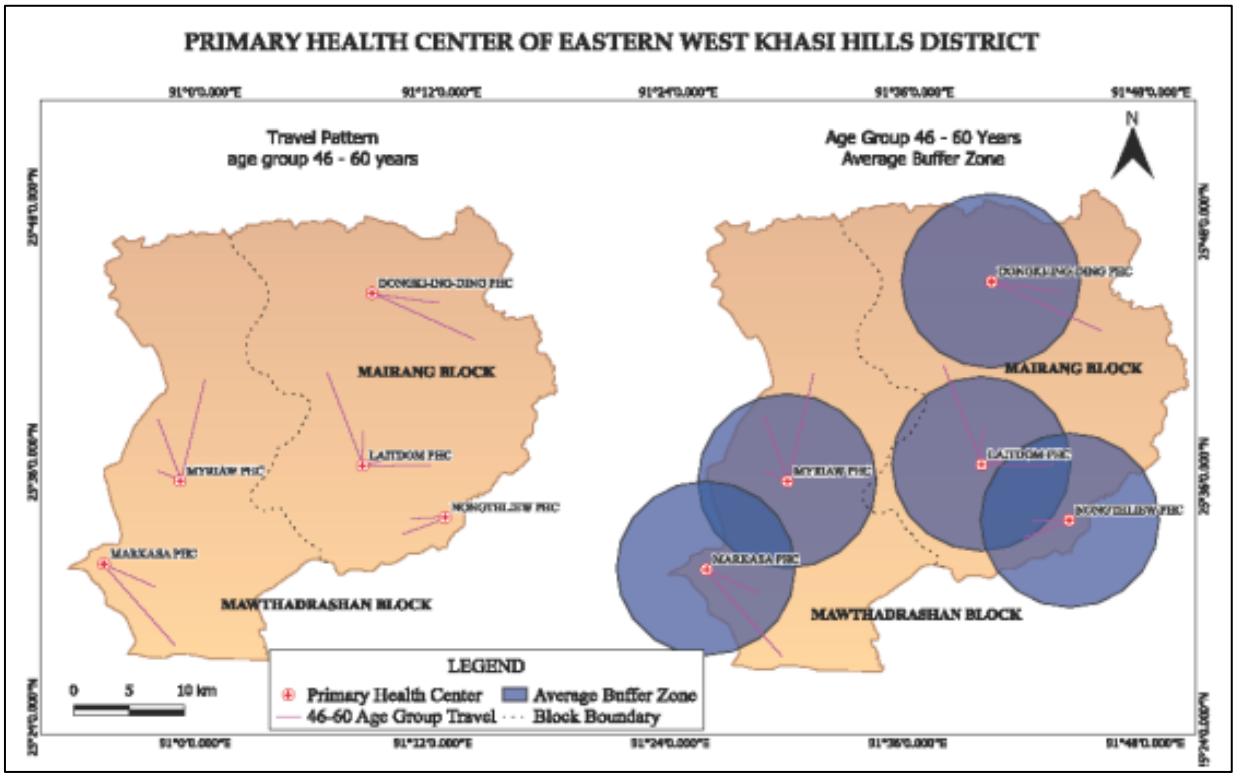

Figure 6 Travel Patterns of the 46-60 Age Group

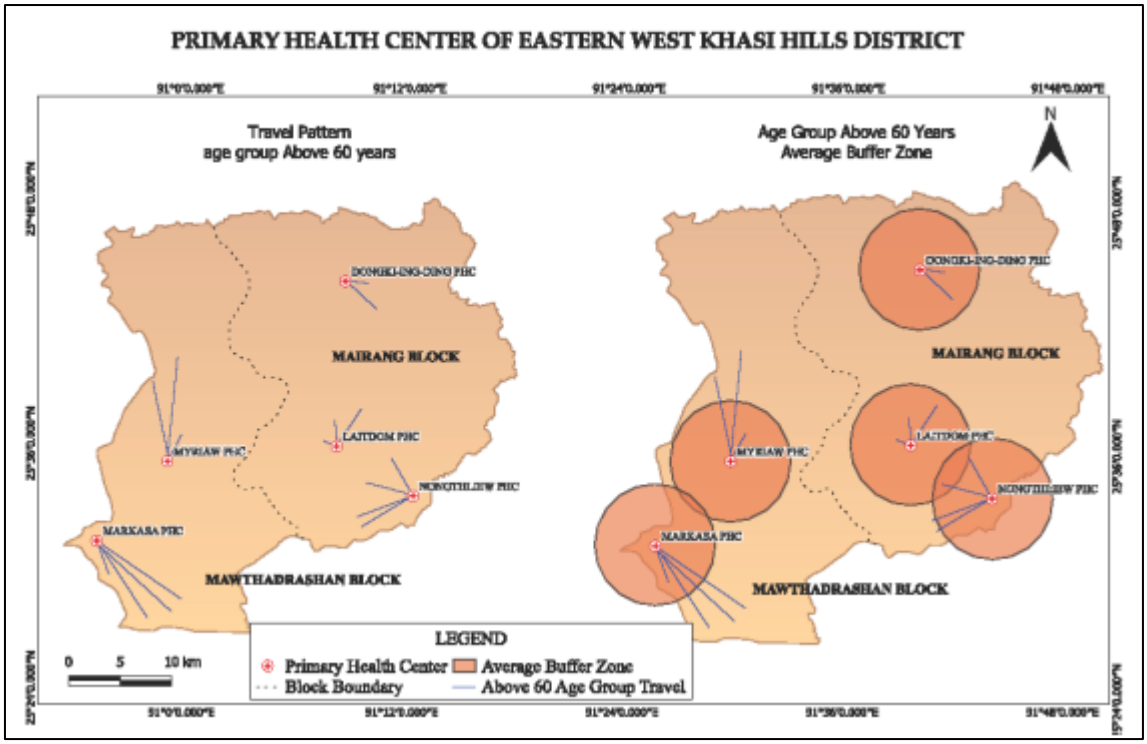

Figure 7 Travel Patterns of the above 60 Age Group

The overlay analysis confirms that accessibility patterns vary spatially across the district. Myriaw, Markasa, and Laitdom PHCs show relatively concentrated travel patterns within average buffer zones, indicating lower travel burden. Conversely, Nongthliew and Dongki-ing-ding PHCs demonstrate wider service areas, suggesting dependence on these facilities by populations located farther away.These findings indicate that healthcare accessibility is shaped by the interaction between age, geographical location, and the spatial distribution of healthcare facilities. Settlements outside overlapping accessibility zones experience greater travel requirements and may require improved transportation connectivity and healthcare planning interventions.

3.4. Utilization Pattern of Selected Primary Health Centres

The utilization analysis was based on responses from 100 patients, with 20 respondents interviewed from each selected PHC. The findings represent the utilization characteristics of surveyed patients and provide insight into age distribution, healthcare services accessed, and factors influencing PHC use.

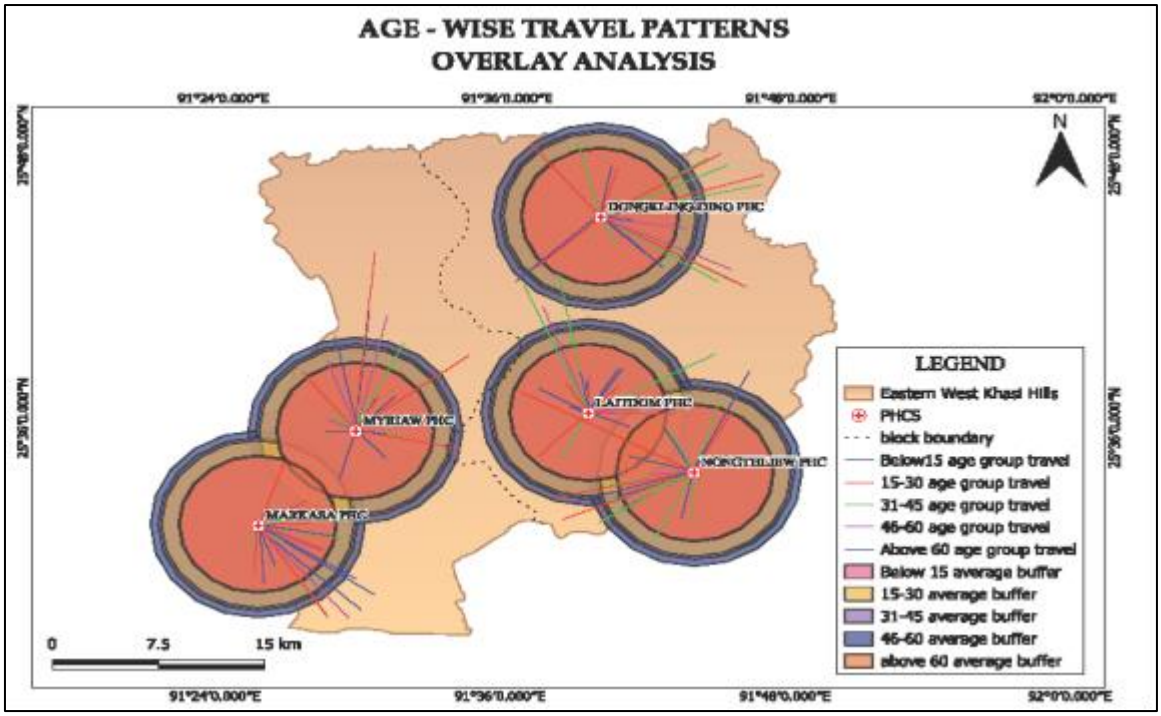

Figure 8 Overlay Analysis of the different Age-Wise Travel Patterns

Respondents belonging to the 31–45 years age group recorded the highest utilization of PHC services, followed by the 15–30 years age group. The dominance of these age groups reflects their greater involvement in household healthcare decisions, occupational activities, and awareness of available health services.Children below 15 years and elderly respondents above 60 years constituted a smaller proportion of PHC users. Their lower representation may be associated with dependence on caregivers, reduced mobility, and preference for nearby healthcare facilities (Figure 8).General treatment was the most frequently utilized service among respondents, followed by maternal and child healthcare, immunization, and follow-up consultations. This highlights the continued importance of PHCs as primary points of healthcare contact for rural communities.

3.5. Comparative Utilization of Selected PHCs

Among the selected facilities, Markasa PHC demonstrated relatively high utilization among productive-age groups. Shorter travel distances and positive perceptions regarding healthcare services contributed to regular use of the facility.Nongthliew PHC showed balanced utilization across age groups and served as an important healthcare centre for surrounding settlements. Regular use of outpatient treatment, immunization, maternal healthcare, and follow-up services indicates its integration into local healthcare practices (Table 2).Laitdom PHC displayed moderate utilization across different age groups. Although accessibility was relatively favourable, concerns related to medicine availability, waiting time, and service satisfaction influenced patient perceptions.

Table 2 Utilization of the five PHCs

Aspect	Key Findings
Data Source	Analysis is based on responses from 20 patients at each selected PHC (Total = 100 respondents).
Age-wise Utilization	Respondents aged 31–45 years recorded the highest utilization of PHC services.
Healthcare Services Utilized	General treatment was the most frequently utilized service, followed by maternal and child healthcare, immunization, and follow-up care.
Travel Pattern	Productive-age adults travelled longer distances than children and elderly respondents to utilize PHC services.

Overall Observation	PHC utilization varied according to age group and the healthcare services utilized by the respondents.

Dongki-ing-ding PHC attracted considerable utilization despite longer travel distances and challenging terrain conditions. Its continued use reflects the importance of the facility within remote rural areas where alternative healthcare options are limited.Myriaw PHC demonstrated balanced utilization and served a wide range of healthcare needs, including general treatment, maternal and child healthcare, and preventive services. Improvements in service environment and cleanliness may further enhance patient satisfaction.

3.6. Overall Discussion

The findings demonstrate that healthcare accessibility and utilization in Eastern West Khasi Hills District are strongly influenced by age-related mobility patterns and geographical conditions. Productive-age populations show greater mobility and travel longer distances to access healthcare services, whereas children and elderly populations depend more on nearby facilities.The study also reveals that travel distance alone does not determine healthcare utilization. PHCs located farther from settlements continue to attract patients due to service availability, community trust, and limited healthcare alternatives. Therefore, accessibility should be understood as a combination of spatial proximity, transportation conditions, service quality, and population characteristics.The results emphasize the need for age-sensitive and geographically balanced healthcare planning. Improving road connectivity, strengthening PHC services, and ensuring equitable distribution of healthcare facilities can reduce travel burden and enhance healthcare accessibility among rural populations in Eastern West Khasi Hills District.

4. Conclusion

The present study examined age-wise travel patterns, spatial accessibility, and utilization of selected Primary Health Centres (PHCs) in Eastern West Khasi Hills District. The findings reveal that healthcare accessibility is influenced by the combined effects of age, mobility characteristics, geographical conditions, and the spatial distribution of healthcare facilities.The analysis of travel patterns indicates significant variation among different age groups. Respondents belonging to the 46–60 years age group recorded the highest mean travel distance (7.57 km), followed by the 31–45 years age group (7.04 km), reflecting greater mobility and willingness to travel for healthcare services. In contrast, children below 15 years and elderly respondents above 60 years showed shorter travel distances, indicating their greater dependence on caregivers and preference for nearby healthcare facilities.The spatial accessibility analysis through buffer and overlay techniques demonstrates that healthcare access varies considerably across the district. PHCs such as Myriaw, Markasa, and Laitdom exhibit comparatively favourable accessibility, with a larger proportion of respondents travelling within average buffer distances. However, Nongthliew and Dongking-ding PHCs serve wider catchment areas, indicating that populations from dispersed settlements often travel longer distances to access healthcare services.

The utilization analysis of the selected PHCs, based on 100 surveyed respondents, shows that productive-age groups, particularly 31–45 years and 15–30 years, constitute the major users of PHC services. General treatment emerged as the most frequently utilized service, followed by maternal and child healthcare, immunization, and follow-up consultations. The findings suggest that PHCs continue to function as essential healthcare providers for rural communities by meeting both preventive and curative healthcare needs.The study further demonstrates that physical distance alone does not determine healthcare utilization. Factors such as availability of services, quality of healthcare delivery, patient satisfaction, road connectivity, and community trust significantly influence healthcare-seeking behaviour. Some PHCs continue to attract patients from distant settlements due to better service availability and limited alternatives.Overall, the study highlights the importance of incorporating age-specific mobility patterns and spatial characteristics into rural healthcare planning. Improving transportation connectivity, strengthening healthcare services, and ensuring balanced distribution of PHCs can reduce travel barriers and enhance equitable access to primary healthcare in Eastern West Khasi Hills District.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare no conflict of interest.

Statement of ethical approval

The study was conducted following institutional ethical guidelines.

Statement of informed consent

Informed consent was obtained from all participants prior to data collection.

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