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Assessing Health Disparities in Cold Desert Ladakh: A Composite Index Analysis of Tribal Communities in Kargil District

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ABSTRACT

The present study assesses the quality of health in the cold desert district of Kargil, Ladakh, using a multidimensional framework grounded in environmental, infrastructural, and nutritional indicators. Recognizing health as a holistic construct the research integrates both primary and secondary data collected through a mixed-methods approach. A total of 391 households were surveyed across nine administrative blocks using a structured questionnaire, supplemented by official records from health, census, and municipal departments. The study employs a Composite Score Index to synthesize ten key variables, including morbidity ratio, access to clean water, waste management, sewerage facilities, and Body Mass Index (BMI). The findings reveal significant intra-block disparities. These spatial inequalities underscore the influence of environmental conditions on health, especially in remote, high-altitude regions. The study concludes with policy recommendations emphasizing targeted infrastructure development, community-based health interventions, and longitudinal monitoring mechanisms to address systemic vulnerabilities and promote equitable health outcomes across Kargil.

Keywords: *Quality of Health, Composite Score Index, Environmental Infrastructure, Kargil, Public Health Disparities, Cold Desert*

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Introduction

The World Health Organization (WHO) defines health as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity" [1]. This holistic view underscores the integral role of health in human development, economic growth, and overall well-being. Health is both a driver and an indicator of development. Enhancing population health is a primary objective of developmental processes, as it supports economic productivity and reflects societal progress. The measurement of health outcomes should encompass not only the prevalence and severity of diseases but also indicators of well-being, which can be assessed through improvements in healthcare quality and accessibility [2]. The quality of health is a multifaceted concept, encompassing physical, mental, and social dimensions as perceived by individuals and communities. It is influenced by various determinants, including socioeconomic status, environmental conditions, and access to healthcare services [3].

Environmental factors play a significant role in health outcomes. Poor housing conditions, such as inadequate sanitation, exposure to indoor air pollution, and overcrowding, are linked to higher morbidity and mortality rates [4]. For instance, studies have shown that substandard housing contributes to respiratory infections, asthma, and other health issues. [5]. Additionally, environmental risks like air and water pollution are responsible for a substantial portion of the global disease burden [6]. Understanding the quality of life (QoL) requires exploring the interplay between economic, biophysical, sociocultural, and political factors to identify the primary determinants of health and well-being.

Research indicates that poverty adversely affects various aspects of family life, including health, by limiting access to nutritious food, safe housing, and healthcare services. Waste management practices also impact health conditions. Improper waste disposal can lead to environmental contamination and the spread of diseases. [7]. Addressing these issues requires comprehensive strategies that consider the socioeconomic and environmental contexts of communities.

Given these considerations, the present research aims to assess the quality of health among the tribal populations of the cold region of Kargil-Ladakh. By examining the interrelated factors influencing health in this unique geographical and cultural setting, the study seeks to contribute to the broader understanding of health disparities and inform targeted interventions.

Study area

Kargil district, one of two districts within the Union Territory of Ladakh, spans approximately 14,036 km^2 between 30–35° N latitude and 75–77° E longitude [8], with elevations varying from 2,676 m in Kargil town to peaks exceeding 7,000 m. Its landscape is dominated by four principal valleys—Suru, Drass, Indus, and Upper Sindh (Kanji Nallah)—intersected by high-altitude passes such as Zojila (3,567 m) and Fotulla (4,192 m), which collectively define its rugged, high-altitude cold desert environment [9]. The region experiences pronounced thermal extremes, with winter temperatures dipping below −45 °C and summer peaks reaching +35 °C, accompanied by substantial diurnal variations. Annual precipitation remains low, ranging between 100–320 mm—primarily in the form of snow—limiting agriculture to a single cereal crop per year, sustained by glacial melt .According to the 2011 Census, Kargil had a population of approximately 140,802, predominantly rural (88.4 %), with a sparse population density of roughly 10 persons/km², a sex ratio of 810 females per 1,000 males, and a literacy rate of 71.3 %, with notable gender disparity favouring males. The district's population is overwhelmingly Muslim (~77 %, mainly Shia), with a Buddhist minority (~14 %), and smaller Hindu, Sikh, and Christian communities. Approximately 87 % belong to Scheduled Tribes, speaking languages including Purgi, Shina, Urdu, with Balti and Shina dialects prevalent across different valleys. This synthesis of high-altitude cold desert geography, dispersed valley settlements, and diverse tribal socio-demography constitutes an essential framework for analyzing health dynamics in this remote mountainous region [10].

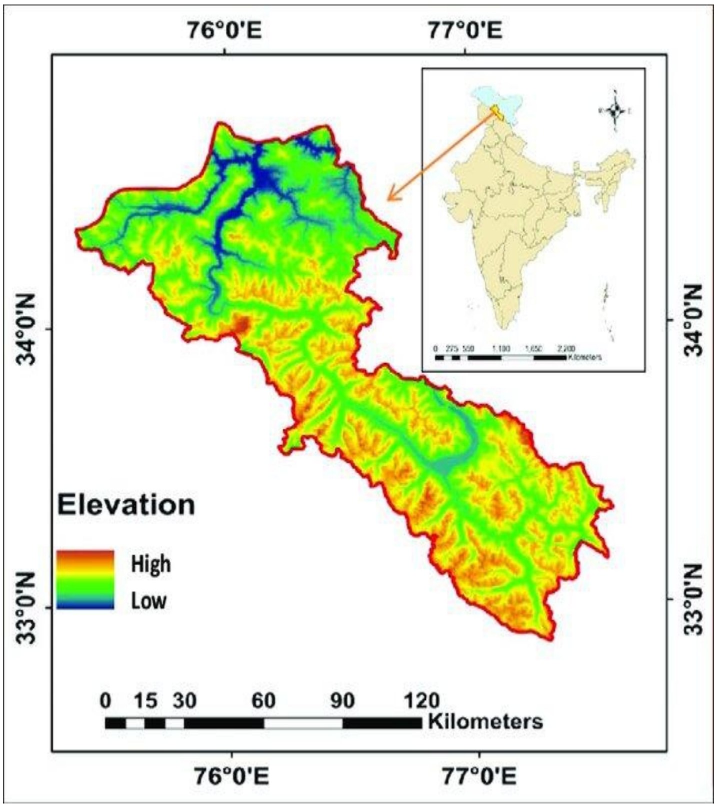

Figure 1: Location map of Study area

Database and Methodology

This study utilized a mixed-methods design, integrating both primary and secondary data to examine the quality of health in Kargil. Primary data were obtained through a household survey, using a structured questionnaire administered across all nine administrative blocks of Kargil district. A two-stage sampling design was implemented: first, blocks were selected as primary sampling units, and second, households within each block were chosen via simple random sampling. A total of 391 households were surveyed, with sample sizes per block proportionally allocated according to their respective household populations, using Slovin's formula for sample size determination . Secondary data—covering demographic, socioeconomic, and health indicators—were sourced from the Department of Census, Directorate of Economics and Statistics, and the Directorate of Health and the Chief Medical Officer's Office in Kargil, supplemented by municipal records from the Kargil Municipal Corporation. This comprehensive approach, combining rigorous primary sampling and authoritative secondary data, provides a robust basis for assessing health status within the region's complex socio-demographic and geographic landscape.

Table 1: Sample Frame

Blocks	Total Households	Household Percentage	Sample Households
Drass	2149	11.72	46
Kargil	5484	29.91	117
GM- Pore	1482	8.08	32
Sankoo	2340	12.76	50
Shankar -Chiktan	1609	8.77	34
Shargole	1625	8.86	35
Taifsuru	1322	7.21	28
Zanskar	1991	10.86	42
Lungnak	336	1.83	7
Total	18338	100.00	391

Computation of the composite index of Quality of Health

The composite score technique is a widely employed research methodology aimed at synthesizing multiple variables or indicators into a consolidated score [11]. This method is extremely useful when dealing with multidimensional notions or occurrences that are difficult to quantify using a single metric [12]. The process involves selecting key variables, such as income, education, and healthcare access, followed by normalizing the data to ensure uniformity across different scales [13]. For determining the quality of health, composite index and standard deviation techniques have been used. In the present study, 10 relevant variables (Table 2) pertaining to health have been taken into consideration. Reasonable weightages were assigned to each variable. Composite scores of all variables are taken, and the mean value was calculated for each block and finally, a comparative analysis was done to show the levels of quality of health in different blocks [14].

Table 2: Variables used for Quality of Health Assessment

S.no	Variables
1	Morbidity Ratio
2	Health Institutes per Thousand population
3	Percentage of Households with Regular Water Supply
4	Percentage of Households with Dustbin Availability
5	Percentage of Households with Regular Dustbin Removal
6	Percentage of Households with Sewerage Facility
7	Percentage of Households with Closed Sewerage
8	Percentage of Wastage Disposal (Dustbin, Roadside, Neighbouring Plots)
9	Body Mass Index (Normal, Obese, Underweight)

Results and Discussion

Table 3 shows the block-wise distribution of selected variables used to assess the Quality of Health across nine administrative blocks in Kargil district, Ladakh, encompassing indicators- morbidity ratio and health institution density, access to regular water supply, availability and removal of dustbins, sewerage facility, and waste disposal methods and nutritional status measured through Body Mass Index categories—normal, obese, and underweight. It provides a multidimensional snapshot of the district's health environment, highlighting significant spatial disparities in infrastructure, service access, and health outcomes, which serve as the empirical foundation for the composite index analysis and subsequent policy recommendations aimed at addressing intra-district inequalities.

Table 3: Values of the Selected Variables used for Quality of Health Assessment.

Block	Morbidity Ratio	H.I/ 000 pop.	Households with Regular Water Supply (%)	Households with Dust bin availability (%)	Households with Dustbin Removal (%)	Households with Sewerage Facility (%)	Households with Closed Sewerage (%)	Wastage Disposal (%)			Body Mass Index (%)		
								Dustbin	Roadside	Neighbo -During plots	Normal	Obese	U. W
Drass	17.64	0.8	82.61	60.14	69.57	30.43	8.70	69.57	0.00	30.43	91.70	4.60	3.70
Kargil	11.96	1.5	82.90	80.50	52.99	66.67	47.86	11.11	15.38	73.51	88.88	3.00	8.12
G. M Pore-Trespone	20.14	1.2	74.60	0.00	0.00	28.00	0.00	19.05	14.29	66.67	85.71	4.76	9.52
Sankoo	20.15	0.8	72.00	0.00	0.00	43.75	0.00	72.00	8.00	20.00	90.75	4.25	5.00
Shankar Chiktan	11.62	1.8	88.89	22.22	22.22	66.67	0.00	22.22	22.22	55.56	79.41	14.70	5.89
Shargole	20.86	1.4	81.00	0.00	0.00	75.00	0.00	68.57	0.00	31.43	85.71	8.57	5.72
Taifsuru	16.09	1.7	20.00	0.00	0.00	20.00	0.00	28.57	0.00	71.43	85.71	3.57	10.72
Zanskar	13.14	1.7	88.24	30.00	35.29	76.47	0.00	47.06	11.76	41.18	76.47	5.88	17.65
Lungnak	18.06	4.7	50.00	0.00	0.00	25.00	0.00	28.57	28.57	42.86	71.42	14.29	14.29

***Source:** Computed from the Data obtained from the field survey*

The findings revealed substantial spatial inequalities. Kargil block recorded the highest composite score (0.913), followed by Zanskar (0.738) and Drass (0.689), reflecting relatively robust environmental health infrastructure in these areas. In contrast, Taifsuru (0.203) and Lungnak (0.288) emerged as the most underdeveloped blocks in terms of environmental health determinants (Table 4).

Mid-tier blocks such as Shankar Chiktan (0.680) and Shargole (0.559) demonstrated a mixed profile—adequate water access and nutrition levels coexisting with deficient sewerage infrastructure and inconsistent waste disposal systems. The observed disparities highlight significant geographic inequities in basic service provision across the district. Lower-performing blocks with limited piped water access and insufficient sanitation infrastructure correlated with higher morbidity and lower BMI, emphasizing the vital role of environmental conditions in shaping health outcomes. These findings are consistent with earlier studies conducted in other regions of India, where inadequate infrastructure has been closely linked to poorer health indicators [15,16]. Sanitation and waste management emerged as critical dimensions influencing environmental health. Blocks like G.M. Pore, Taifsuru, and Lungnak lacked organized waste removal systems and proper dustbin availability, increasing exposure to disease-causing agents. Furthermore, differences in nutritional well-being—reflected in BMI data—underscore the multi-layered impacts of environmental determinants, particularly in high-altitude, climatically extreme, and geographically inaccessible regions [17,18].

The Composite Score Index outcomes demonstrate the need for geographically targeted yet integrated policy measures. For the most underperforming blocks—especially Taifsuru and Lungnak—urgent investment in basic environmental infrastructure is required. This includes expansion of piped water systems, construction of functional sewerage networks, and the establishment of community-level waste collection and disposal mechanisms. In moderately performing areas, such as Shargole and G.M. Pore, policy should focus on operational improvements—ensuring regular waste removal, expanding dustbin coverage, and improving maintenance of existing sanitation infrastructure.

Health-specific interventions must complement infrastructural development. These include nutrition awareness campaigns, immunization programs, community hygiene education, and mobile health outreach, especially in rural and tribal areas where systemic vulnerabilities are more pronounced. Furthermore, a robust monitoring and evaluation framework, utilizing longitudinal updates of the Composite Score Index, will be essential for tracking spatial progress and informing course corrections. Future iterations of the index should also incorporate additional health indicators, such as indoor air quality, under-five stunting rates, and the prevalence of non-communicable diseases, to offer a more holistic understanding of health-environment linkages in cold desert geographies.

These policy directions are substantiated by global and national literature. Sharma et al., [19] argue that improving water and sanitation directly reduces childhood mortality and disease incidence. Similarly, Nelson et al. [20], Rather [21] established the importance of sanitation infrastructure in lowering community health risks. Karnar et al.,[22], Thresia et al. [23], and Rather [24] demonstrate that inadequate waste disposal and substandard housing increase vulnerability to malnutrition and chronic illness, particularly among tribal and marginalized populations. Furthermore, Riva et al.,[25] link environmental cleanliness and secure housing conditions with physical and psychological well-being. This study reinforces these findings, highlighting that spatially disaggregated composite indicators are essential for diagnosing public health challenges and planning geographically responsive interventions.

Table 4: Composite Scores of the Selected Variables of Quality of Health Assessment.

Block	Morbidity	Water	Dustbin Availability	Sewerage	Dustbin Removal	BMI	Composite Score Index
Drass	0.560	0.906	0.747	0.194	0.851	0.877	0.689
Kargil	0.963	0.883	1.000	0.830	0.945	0.857	0.913
G.M. Pore	0.000	0.808	0.000	0.141	0.771	0.701	0.403
Sankoo	0.000	0.742	0.000	0.421	0.841	0.877	0.480
Shankar Chiktan	1.000	1.000	0.276	0.830	0.572	0.400	0.680
Shargole	0.000	0.855	0.000	0.974	0.822	0.701	0.559
Taifsuru	0.513	0.000	0.000	0.000	0.000	0.701	0.203
Zanskar	0.815	0.987	0.373	1.000	1.000	0.255	0.738
Lungnak	0.309	0.428	0.000	0.089	0.904	0.000	0.288

***Source:** Computed from the Data obtained from the field survey*

Conclusion

The present research highlights significant intra-district disparities in environmental health infrastructure across Kargil, as captured through the Composite Score Index. While blocks such as Kargil, Zanskar, and Drass exhibit relatively strong infrastructure and health outcomes, others—particularly Taifsuru and Lungnak—face pronounced deficits in water supply, sanitation, and waste management systems. These disparities are emblematic of the broader challenges faced by ecologically fragile and geographically isolated regions, where infrastructural development is often uneven and access to basic services remains inadequate.

The study not only supports the growing body of literature that links environmental factors with health outcomes—including morbidity, nutritional status, and general well-being—but also offers a practical, data-driven framework for policy prioritization and targeted intervention. A multi-sectoral, equity-oriented development strategy that integrates physical infrastructure with preventive health programs is essential for addressing these systemic gaps. Ultimately, strengthening environmental health infrastructure in Kargil is not just a matter of improving physical conditions but a foundational step toward achieving social justice, sustainable development, and resilience in one of India's most remote and vulnerable regions.

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