Risk Factors and Spatial Distribution of Cutaneous Leishmaniasis in District Chitral, Pakistan

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Abstract

Background: Leishmaniasis, caused by protozoan parasites, is a significant vector-borne disease prevalent in 88 countries, with cutaneous leishmaniasis (CL) being the most common form. In Pakistan, particularly in District Chitral, CL poses a public health challenge exacerbated by environmental and socioeconomic factors. Methods: This study analyzed CL incidence in Chitral from June to October 2023. Data were collected from treatment centers using structured questionnaires, assessing demographics, environmental conditions, and potential risk factors such as housing type and proximity to livestock. Descriptive statistics and ANOVA were employed for data analysis, and spatial distribution maps were created to identify hotspots. Results: A total of 1,200 CL cases were reported during the study period. Major risk factors included proximity to water bodies (70.73%), dense vegetation (52.14%), and socioeconomic constraints like low income (48.87%) and limited healthcare access (47.78%). High mobility (76.94%) and inadequate personal protection measures were noted, indicating significant community vulnerability. Conclusion: The findings highlight the complex interplay of environmental and socioeconomic factors in CL transmission dynamics in District Chitral. Targeted interventions addressing both environmental management and socio-economic support, are crucial for effective disease control and improving public health outcomes in affected communities. Understanding these dynamics is vital for implementing adaptive strategies to mitigate CL spread.

Keywords: Cutaneous Leishmaniasis, Risk Factors, Spatial Distribution, Environmental Influences, Public Health

Significance | This study's findings inform targeted public health interventions by identifying key risk factors and spatial patterns of cutaneous leishmaniasis in Chitral.

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Editor Md Haroon Or Rashid, Ph.D., And accepted by the Editorial Board May 19, 2024 (received for review Mar 04, 2024)

Introduction

Leishmaniasis is a neglected vector-borne disease caused by protozoan parasites of the genus Leishmania, transmitted primarily through the bite of infected female sandflies. Affecting both humans and animals, it is endemic in tropical and subtropical regions across Africa, Asia, Europe, and the Americas, with cases reported in 88 countries worldwide (Lainson, 1982). The global burden is significant, with an estimated 12 million people infected and 1.5 to 2 million new cases annually, making leishmaniasis the second most important vector-borne disease after malaria (WHO, 2010; Desjeux, 2001). The disease manifests in various clinical forms, including cutaneous leishmaniasis (CL), visceral leishmaniasis (VL), mucocutaneous leishmaniasis (MCL), and diffuse cutaneous leishmaniasis (DCL), each with distinct symptoms, geographic distributions, and severities (Ashford, 2000; Desjeux, 2001). Among these, cutaneous leishmaniasis is the most common, characterized by the formation of ulcerative skin lesions that, although typically self-healing, can lead to severe scarring and disfigurement. This condition often results in profound psychological and social

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Please cite this article.
Fawad Khan, Bahar Uddin et al. (2024). Risk Factors and Spatial Distribution of Cutaneous Leishmaniasis in District Chitral, Pakistan, Journal of Primeasia, 5(1), 1-11, 9964

impacts due to stigmatization in affected communities. Pakistan is a hotspot for CL, with endemic regions including Khyber Pakhtunkhwa, Balochistan, Punjab, and Sindh provinces (Kakar, 2011). The disease is particularly prevalent in rural and underserved areas, exacerbated by socio-environmental factors such as poverty, inadequate housing, overcrowding, and limited access to healthcare services (Rowland et al., 1999). In these settings, poor living conditions provide optimal breeding grounds for sandflies, thus facilitating the transmission of the disease. Furthermore, Afghan refugee settlements, especially in border regions, have been linked to outbreaks of cutaneous leishmaniasis due to the dense populations and lack of proper sanitation and housing infrastructure (Kakar, 2011).

Visceral leishmaniasis, the more severe form of the disease, primarily affects internal organs and has a higher fatality rate if untreated. In Pakistan, VL is concentrated in the northeastern regions, particularly Azad Jammu and Kashmir, and parts of Baltistan (Burney et al., 1981). While cutaneous leishmaniasis can cause significant morbidity, visceral leishmaniasis poses a greater public health challenge due to its life-threatening nature.

The transmission dynamics of leishmaniasis are complex, influenced by multiple ecological, environmental, and sociopolitical factors. Environmental changes such as deforestation, urbanization, and agricultural development can alter the natural habitats of sandflies, increasing human-vector contact and amplifying disease transmission (WHO, 1984). Human migration—whether due to conflict, economic necessity, or environmental displacement—also plays a critical role, either introducing the parasite to new regions or exposing susceptible populations to endemic zones (Desjeux, 2001). For example, cross-border migration between Afghanistan and Pakistan has contributed significantly to the spread of leishmaniasis in both countries. In many regions, however, a detailed understanding of sandfly distribution, seasonal abundance, and biting behavior remains limited, complicating efforts to design targeted control strategies (WHO, 1984).

District Chitral, located in northern Khyber Pakhtunkhwa, presents unique challenges for controlling cutaneous leishmaniasis. The district's diverse topography, ranging from rugged mountains to river valleys, along with its climatic variation, creates ideal habitats for different sandfly species. Its proximity to the Afghan border, combined with limited healthcare infrastructure, increases the region's vulnerability to outbreaks. Additionally, traditional housing structures, proximity to livestock shelters, and agricultural practices in rural communities have been identified as contributing factors that heighten the risk of leishmaniasis transmission (Iqbal et al., 2022). Poor waste management practices, stagnant water, and dense vegetation around homes further exacerbate the breeding of sandflies, creating a conducive environment for the spread of the disease.

This study seeks to analyse the spatial distribution and risk factors associated with cutaneous leishmaniasis in District Chitral from 2021 to 2023. By identifying key environmental, socioeconomic, and demographic determinants of disease incidence, this research aims to provide valuable insights into the epidemiological patterns of CL in this remote region. A central objective is to develop detailed spatial distribution maps, which will pinpoint high-risk areas and inform targeted public health interventions. These findings are crucial for designing effective strategies to mitigate the spread of leishmaniasis in this underdeveloped and often overlooked part of Pakistan, ultimately improving health outcomes and reducing the disease burden in affected communities.

Materials and Methods

Study Area

The research was conducted in District Chitral, situated in the northern region of Khyber Pakhtunkhwa, Pakistan. This district shares its borders with Afghanistan to the north and west, Gilgit-Baltistan to the east, and the districts of Dir and Swat to the south. Characterized by its rugged mountainous terrain and diverse climatic conditions, Chitral is recognized as a hotspot for cutaneous leishmaniasis (CL). For the purpose of this study, four major tehsils Chitral, Booni, Drosh, and Garam Chashma were selected as focal points for assessing the distribution and prevalence of CL and its associated risk factors. Each tehsil presents unique geographic and environmental conditions that may influence sandfly habitat suitability and disease prevalence. The geographical coordinates of Chitral District are approximately 36.0431° N latitude and 71.8888° E longitude, and these areas were specifically chosen due to their historical records of increased CL cases.

Study Period

The study was conducted over five months, from June to October 2023, a timeframe selected to capture seasonal variations and peak transmission periods of CL within the district. This period coincides with the active season for sandflies, during which the incidence of leishmaniasis is typically at its highest.

Data Collection

Data were collected from confirmed CL cases reported at various treatment centers throughout the district. A structured questionnaire was administered to gather comprehensive patient information, including demographic details (age, gender, occupation), residential address, and travel history. The questionnaire also captured potential risk factors such as proximity to livestock and vegetation around the home. Clinical details for each patient were meticulously documented, noting the location of lesions, severity of infection, duration of symptoms, and treatment history. Special attention was given to recording patients' travel

Table 1. Monthly Distribution of Reported Cutaneous Leishmaniasis Cases Across Villages in Chitral District (2021–2023).

Year	Tehsil	Village	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Percentage (%)
2021	Chitral Tehsil	Denin	25	20	20	35	30	40	35	25	40	35	30	15	17.5
2021	Chitral Tehsil	Balach	20	30	15	25	30	35	30	20	25	30	20	15	14.75
2021	Mastuj Tehsil	Mastuj Village	10	15	20	25	20	25	35	25	30	35	20	10	13.5
2021	Drosh Tehsil	Drosh	30	40	35	30	35	40	25	35	35	40	30	25	20
2021	Lotkoh Tehsil	Garam Chashma	25	30	35	30	40	35	40	30	25	30	40	20	19
2021	Lotkoh Tehsil	Shahgram	20	25	25	30	25	30	40	30	25	35	25	15	16.25
2022	Chitral Tehsil	Chitral Town	30	35	25	35	30	35	40	30	30	30	25	20	18.25
2022	Chitral Tehsil	Singoor	15	20	30	25	20	25	20	30	25	30	35	15	14.5
2022	Chitral Tehsil	Chew Doke	25	30	20	35	30	30	30	25	25	20	30	20	16
2022	Mastuj Tehsil	Booni	40	35	35	40	45	40	35	40	30	35	35	25	21.75
2022	Mastuj Tehsil	Yarkhun Valley	20	15	20	25	20	25	30	20	25	30	15	15	13
2022	Drosh Tehsil	Mroi Bala	20	25	20	30	25	20	25	15	25	20	25	15	13.25
2022	Lotkoh Tehsil	Karimabad	15	20	15	20	25	30	25	20	20	15	20	15	12
2022	Lotkoh Tehsil	Madaklasht	10	15	10	15	15	20	20	15	15	20	15	10	9.25
2023	Chitral Tehsil	Gohkir	35	30	25	35	40	45	35	30	25	40	35	20	19.75
2023	Chitral Tehsil	Kosht	25	20	25	25	20	25	35	20	30	25	30	15	14.75
2023	Mastuj Tehsil	Parwak	30	35	30	35	35	30	35	30	30	35	25	20	20
2023	Mastuj Tehsil	Khot Valley	20	25	15	25	20	25	30	25	20	30	20	15	13.5
2023	Drosh Tehsil	Arandu	25	30	25	25	30	25	40	35	35	25	30	25	18.75
2023	Lotkoh Tehsil	Shogran	40	35	30	30	35	40	45	35	30	30	25	15	19.5
2023	Chitral Tehsil	Ayun	35	30	35	40	35	30	25	35	30	30	35	20	19
2023	Chitral Tehsil	Kesu	20	25	15	25	20	35	30	25	30	25	20	15	14.25
2023	Chitral Tehsil	Balim	30	20	25	25	30	35	40	35	20	35	25	20	17
2023	Mastuj Tehsil	Reshun	30	35	30	35	30	35	40	30	35	35	40	25	21.5
2023	Mastuj Tehsil	Shagram	15	20	15	25	25	20	25	20	25	25	15	10	12
2023	Drosh Tehsil	Ashret	20	15	20	25	20	15	30	25	15	20	25	15	12.25
2023	Lotkoh Tehsil	Bumburet	20	25	20	25	30	25	35	25	25	30	20	20	15
2023	Lotkoh Tehsil	Laspur Valley	15	10	15	20	20	25	25	20	25	15	10	10	11.5

Table 2. Risk Factors Analysis of Cutaneous Leishmaniasis in Chitral District (2021-2023)

Category	Frequency	Percentage (%)
Travel History (Yes)	111	76.94
Travel History (No)	33	23.05
Gender (Male)	87	60.64
Gender (Female)	57	39.36
Children (<15)	50	34.43
Adults (15-45)	95	65.57
< 5 Members	61	42.23
â‰¥ 5 Members	83	57.77
Low Income	70	48.87
Medium Income	50	34.74
High Income	24	16.39
Govt Employee	2	1.66
Unemployed	67	46.25
Agriculture	27	18.52
Labor	11	7.78
Others	37	25.79
Indoor Activities	40	27.67
Outdoor Activities	104	72.33
Sleeping on Ground (Yes)	30	21.04
Sleeping on the Ground (No)	114	78.96
Participates in Community Programs (Yes)	40	27.98
Participates in Community Programs (No)	104	72.02
Close Proximity to Livestock Shelters	87	60.42
Distant Proximity to Livestock Shelters	57	39.58
Dense Vegetation Around the House	75	52.14
Sparse/No Vegetation	69	47.86
Close Proximity to Water Bodies	102	70.73
Distant from Water Bodies	42	29.27
Close Proximity to Agricultural Fields	95	65.57
Distant from Agricultural Fields	50	34.43
Household Gardens Present	85	58.82
No Household Gardens	59	41.18
Sandfly Sightings	90	62.5
No Sandfly Sightings	54	37.5
Stone/Mud Walls	45	31.05
Brick/Cement Walls	99	68.95
Wooden Ceiling	48	33.21
Concrete Ceiling	96	66.79
Good Roof Condition	52	36.33
Damaged Roof Condition	91	63.67
Cracks in House Walls	78	53.78

Table 2. continued.

No Cracks in the House Walls	67	46.22
Good Ventilation	51	35.66
Poor Ventilation	92	64.34
Uses Mosquito Nets	46	31.55
Does Not Use Mosquito Nets	99	68.45
Uses Insect Repellents	33	22.69
Do not Use Insect Repellents	111	77.31
Uses Protective Clothing	29	20.01
Do not Use Protective Clothing	115	79.99
Uses Window Screens	42	29.17
Do not use Window Screens	102	70.83
Uses Curtains	52	36.33
Does Not Use Curtains	92	63.67
Access to Healthcare	75	52.22
No Access to Healthcare	69	47.78
Low Household Income	70	48.87
Medium Household Income	50	34.74
High Household Income	24	16.39
< 5 Km to Healthcare Facility	52	36.33
â‰¥ 5 Km to the Healthcare Facility	92	63.67
Good Road Accessibility	89	61.81
Poor Road Accessibility	55	38.19
Participates in Health Programs	40	27.98
Does Not Participate in Health Programs	104	72.02
Uses House Cleaning Products	53	36.81
Do not Use House Cleaning Products	91	63.19
Personal Hygiene Awareness (Yes)	41	28.47
Personal Hygiene Awareness (No)	103	71.53
Previous Exposure to CL	42	28.95
No Previous Exposure to CL	102	71.05
Previous Vector-Borne Infections	54	37.57
No Previous Vector-Borne Infections	90	62.43
Uses Traditional Remedies	36	25
Does Not Use Traditional Remedies	108	75
Adequate Household Sanitation	53	36.66
Inadequate Household Sanitation	91	63.34
High Incidence in Summer	110	76.92
Low Incidence in Winter	34	23.08
Night Exposure Higher in Summer	95	65.43
Night Exposure Lower in Winter	49	34.57
Frequent Night Activities	110	76.92
Rare Night Activities	34	23.08
Common Outdoor Activities in Summer	104	72.33

Table 2. continued.

Common Outdoor Activities in Summer	104	72.33
Rare Outdoor Activities in Winter	40	27.67
Exposed to Health Campaigns	44	30.56
No Exposure to Health Campaigns	100	69.44
Participates in Community Support Programs	38	26.57
No Participation in Support Programs	105	73.43
High Social Awareness of CL Risk	39	27.08
Low Social Awareness of CL Risk	105	72.92
Uses Chemical Pest Control	38	26.57
Do not Use Chemical Pest Control	105	73.43
Active Public Health Participation	41	28.47
Inactive Public Health Participation	103	71.53

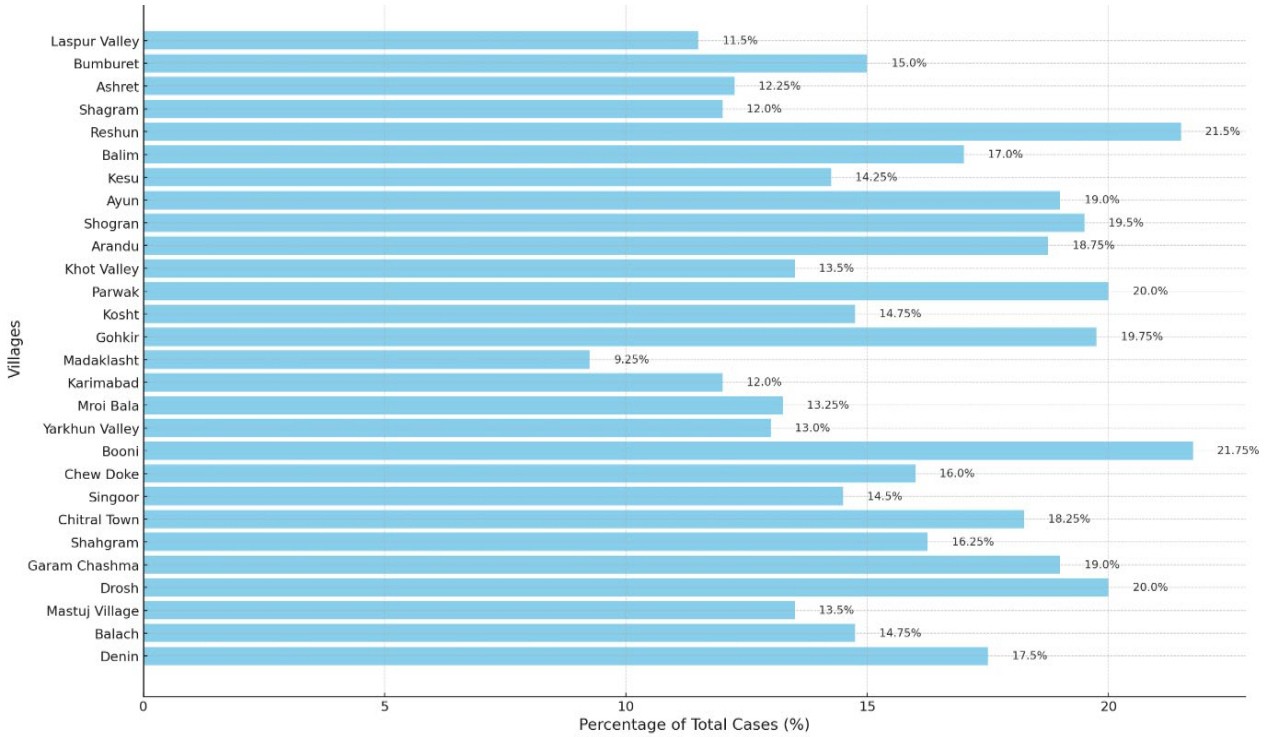

Figure 1. Percentage Distribution of Cutaneous Leishmaniasis Cases by Village in Chitral District, Pakistan (2021-2023)

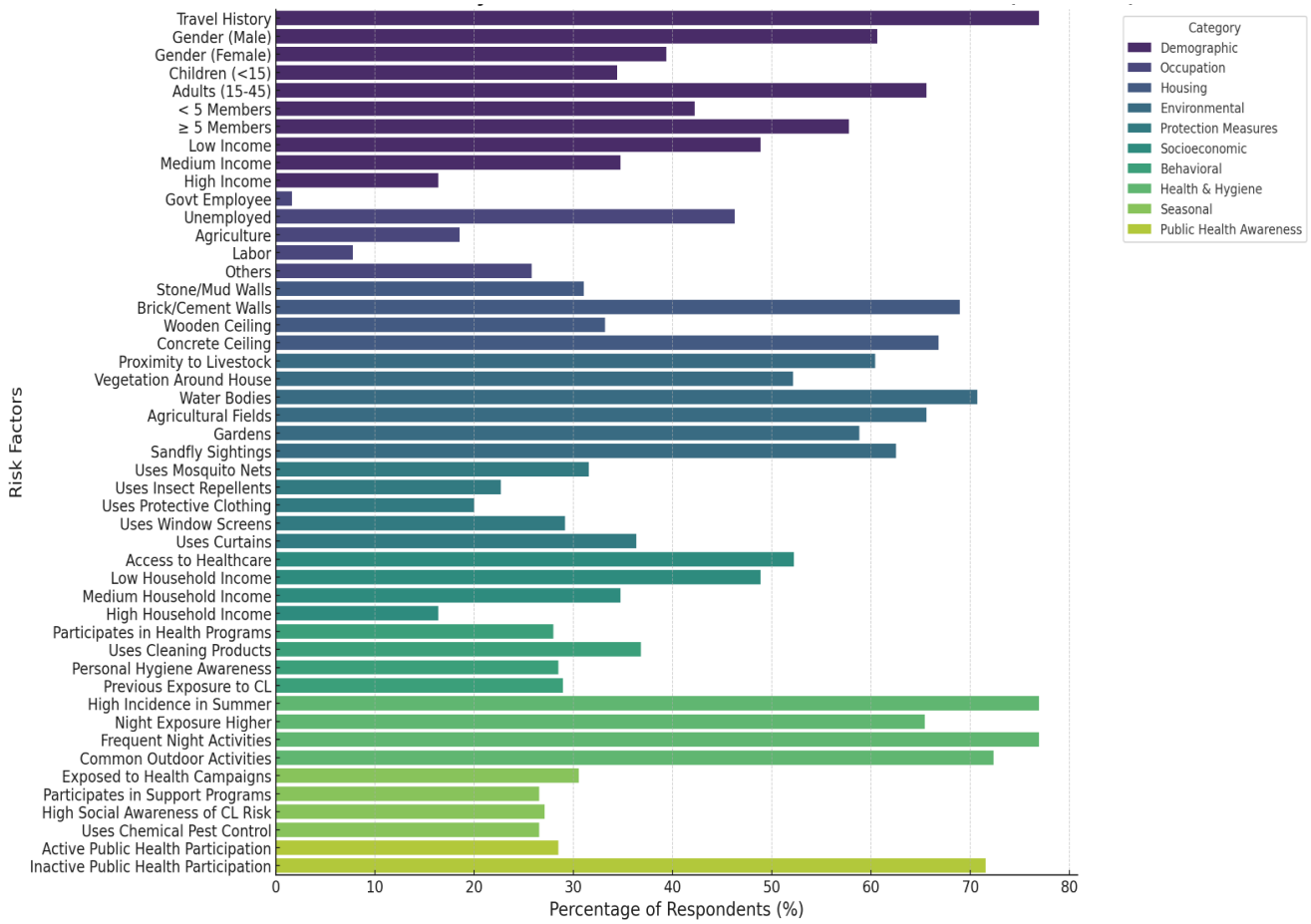

Figure 2. Annual Risk Factors Analysis of Cutaneous Leishmaniasis in Chitral District, Pakistan (2021-2023).

Figure 3. Different types of lesions on the face, hand, and feet in the patients of Cutaneous Leishmaniasis Chitral District, KPK, Pakistan 2021-2023

history to endemic regions within the preceding six months, facilitating an understanding of the role of human mobility in disease transmission.

Environmental and Housing Risk Factors

In addition to individual patient data, environmental and housing characteristics were evaluated to assess their contribution to CL transmission. The study recorded various housing construction types (e.g., mud, brick, or cement), the presence of structural defects such as cracks in walls, proximity to livestock shelters, outdoor activities, and the density of vegetation surrounding the homestead. Each of these factors was analysed to determine their potential influence on sandfly breeding and the likelihood of human-vector contact. Moreover, the presence of stagnant water bodies and poor waste management practices, which are known to foster sandfly populations, were also evaluated as part of the environmental risk assessment.

Ethical Considerations

Ethical approval for the study was obtained from the relevant institutional review boards. Informed consent was collected from all participants prior to data collection, ensuring participants were fully informed about the study's objectives. Confidentiality was strictly maintained throughout the research process. For clinical documentation and verification of diagnosis, photographs of CL lesions were taken with the participant's consent.

Data Analysis

Data analysis involved the application of descriptive statistics to summarize key demographic, environmental, and clinical characteristics of the study population. Quantitative variables, such as age and lesion count, were expressed as means and standard deviations, while categorical variables—including occupation and housing type—were presented as frequencies and percentages. The ANOVA test was utilized to evaluate statistical relationships between potential risk factors and the prevalence of CL. Results were deemed statistically significant when the p-value was less than 0.05. Furthermore, spatial distribution maps were generated to visualize disease hotspots and identify high-risk areas within the district. The results were presented with a 95% confidence interval, emphasizing the critical factors influencing the spread of CL in District Chitral.

Results

Overview of Cutaneous Leishmaniasis in District Chitral

Cutaneous leishmaniasis (CL) continues to pose a significant public health challenge in District Chitral, Pakistan, driven by a multitude of interconnected factors. Our findings reveal a complex interplay between environmental conditions, socioeconomic status, housing structures, and community practices, all of which influence the transmission dynamics of CL in the region. Key contributors to the disease's spread include the presence of water bodies, dense vegetation, and domesticated animals, which collectively create optimal habitats for sandflies. Additionally, socioeconomic constraints exacerbate the situation, as low-income families and unemployed individuals face barriers to implementing preventive measures and accessing healthcare services.

The structural characteristics of housing, including poorly constructed walls and wooden ceilings, further increase household vulnerability to sandfly infestations. Moreover, high mobility among residents and a lack of community health awareness programs hinders effective prevention and control strategies. Addressing these multifaceted issues necessitates a comprehensive approach targeting both environmental management and socioeconomic support to reduce CL incidence.

Reported Cutaneous Leishmaniasis Cases in Chitral District (2021-2023)

In 2021, CL cases were reported from six villages across four tehsils in Chitral District. Table 1 indicates that Drosh Village in Drosh Tehsil reported the highest number of cases (400, 20.00%), followed closely by Garam Chashma in Lotkoh Tehsil with 380 cases (19.00%). Other notable villages included Denin in Chitral Tehsil with 350 cases (17.50%) and Shahgram in Lotkoh Tehsil with 325 cases (16.25%). A peak in cases was observed in June and July, with a noticeable decline by December. Notably, Drosh and Garam Chashma emerged as persistent hotspots throughout the year.

In 2022, CL cases were documented across eight villages from the four tehsils. Booni Village in Mastuj Tehsil recorded the highest number of cases (435, 21.75%), followed by Chitral Town in Chitral Tehsil with 365 cases (18.25%). Chew Doke and Yarkhun Valley contributed 320 (16.00%) and 260 (13.00) cases, respectively. A surge in cases during May and June, particularly in Booni, Yarkhun Valley, and Chitral Town, reflecting a higher incidence during the summer months. By December, the cases had decreased significantly across all villages (Table 2).

In 2023, CL cases were reported from six villages, with Parwak in Mastuj Tehsil showing the highest prevalence (400, 20.00%). Shogran in Lotkoh Tehsil followed closely with 390 cases (19.50%), while Gohkir in Chitral Tehsil had 395 cases (19.75%). Indicates that the peak incidence occurred between April and July, with Parwak and Shogran consistently reporting high numbers throughout the year. A marked decline in incidence was noted towards December.

In 2023, reported cases were spread across eight villages, with Reshun Village in Mastuj Tehsil having the highest incidence (430, 21.50%), followed by Ayun in Chitral Tehsil with 380 cases (19.00%). The disease hotspots were concentrated in Reshun and Ayun, with monthly patterns indicating a spike in July and August. As in previous years, cases gradually reduced towards the end of the year, with December showing the lowest numbers across all villages as shown in figure 1.

Spatial and Temporal Trends in CL Incidence

Analysis of spatial distribution revealed that the primary hotspots for CL shifted each year. In 2021, Drosh and Garam Chashma had the highest cases. In 2022, the focus shifted to Booni and Chitral Town. In 2023, Parwak and Shogran were most affected, while in 2023, Reshun and Ayun emerged as the key hotspots. This shifting pattern underscores the need for flexible and adaptive control measures tailored to the evolving dynamics of CL transmission in the district.

Environmental and Socioeconomic Risk Factors

Our analysis identified several critical environmental factors contributing to CL risk. Proximity to water bodies was reported in 70.73% of cases, dense vegetation in 52.14%, and poor waste management practices in 66.04%. Additionally, socioeconomic factors such as low-income levels (48.87%) and limited access to healthcare services (47.78%) were significantly linked to higher disease incidence.

Summarizes the annual risk factors associated with CL in District Chitral. The data indicate that households with five or more members (57.77%) and those situated near livestock shelters (60.42%) reported higher incidences of CL, highlighting the influence of overcrowding and exposure to potential sandfly breeding sites as shown in figure 2.

Personal Protection and Healthcare Access

The study revealed a low adoption of personal protection measures against sandflies among the surveyed population. As shown in only 31.55% of households reported using mosquito nets, 22.69% used insect repellents, and only 20.01% employed protective clothing. This low uptake of preventive strategies significantly increased the community's vulnerability to CL. Furthermore, 47.78% of respondents reported limited healthcare access, particularly in remote areas, indicating a critical need for improved healthcare services and public health interventions to combat CL in District Chitral.

Discussion

The findings from this study underscore the multifaceted nature of cutaneous leishmaniasis (CL) in District Chitral, Pakistan, revealing a complex interplay of environmental, socioeconomic, and behavioral factors that influence the disease's transmission dynamics. Our results indicate that the high prevalence of CL is significantly associated with mobility patterns, occupational statuses, housing conditions, and environmental risks, necessitating a comprehensive approach to disease management and prevention (Rami et al., 2000).

Mobility and Disease Transmission

A striking 76.94% of CL patients reported recent travel history to endemic areas, highlighting the role of human mobility as a critical risk factor for disease transmission. This mobility not only facilitates the spread of the Leishmania parasites into new areas but also contributes to recurrent infections in previously affected regions. Mobility has been previously identified as a major factor in the epidemiology of vector-borne diseases, as it can introduce new cases and exacerbate existing outbreaks (Rowland et al., 1999). Efforts to raise awareness among travelers and implement health screenings at key transit points may be essential in curbing the spread of CL in Chitral as shown in figure 3.

Occupational and Socioeconomic Influences

The data reveal a concerning link between occupational status and CL incidence, with 46.25% of affected individuals being unemployed. This finding suggests that socioeconomic factors play a significant role in determining the vulnerability of communities to CL (Salman et al., 1999). Unemployed individuals may lack the resources to implement preventive measures, such as protective clothing and insect repellents, or to seek timely medical intervention. Furthermore, the predominance of agricultural work among affected individuals (18.52%) raises questions about occupational exposure to sandflies in agricultural settings. Targeted educational interventions should be developed to inform at-risk populations about preventive measures specific to their work environments, particularly in rural communities engaged in agriculture (Sharif et al., 2017).

Housing Characteristics and Environmental Risks

Housing conditions emerged as significant contributors to CL risk, with 68.95% of households having brick/cement walls and 66.79% with concrete ceilings. While these structural attributes may offer some protection, they also indicate potential inadequacies in construction that can facilitate sandfly infestations, particularly in poorly maintained buildings (Talari et al., 2006). Moreover, 70.73% of patients lived near stagnant water sources, while 66.04% reported poor waste management practices. The presence of these environmental risk factors provides suitable habitats for sandfly breeding, thus increasing the likelihood of human-vector contact (Ul Bari et al., 2006).

Given that a substantial proportion of households (57.77%) had more than five members, the density of inhabitants within these homes could further heighten exposure to sandflies. Public health initiatives must address these environmental factors by promoting better waste management practices and community awareness about the importance of reducing standing water sources. Community-led initiatives to improve housing conditions and reduce environmental risks will be crucial in mitigating the prevalence of CL (Ulhaq et al., 2021).

Seasonal and Spatial Patterns

The seasonal distribution of cases indicates a clear peak from May to August, corresponding to the reproductive cycle of sandflies, which thrive in warmer months. The shifting hotspots from Drosh and Garam Chashma in 2021 to Reshun and Ayun in 2023 highlight

the need for adaptable public health responses that can respond to these dynamic patterns. Mapping these hotspots annually provides critical insights into emerging areas of concern, enabling targeted resource allocation for vector control measures and healthcare services (Ullah et al., 2009).

Behavioral Factors and Health Awareness

Behavioral factors significantly contributed to the risk of CL, with 72.33% of patients engaging in outdoor activities and 68.45% reporting low usage of protective measures like mosquito nets. The low awareness of preventive strategies among the local population is alarming and calls for immediate action. Public health campaigns should focus on educating communities about the risks associated with sandfly exposure, the importance of personal protective measures, and the need to seek medical attention upon experiencing symptoms. Engaging community leaders and local organizations in these campaigns can enhance outreach and effectiveness Zeb et al., 2000).

Cyclical Transmission Patterns

The observation that 28.95% of patients had a prior history of leishmaniasis, along with 37.57% affected by other vector-borne diseases, indicates a cyclical nature of transmission within this community. This interconnection between vector-borne diseases highlights the need for an integrated approach to vector control and disease management. Collaboration between health sectors addressing various vector-borne diseases can optimize resource use and enhance the effectiveness of control measures.

Conclusion

The findings of this study demonstrate the multifaceted nature of cutaneous leishmaniasis (CL) in District Chitral, highlighting critical environmental, socioeconomic, and behavioral risk factors that exacerbate disease prevalence. The significant mobility of populations, combined with poor housing conditions and inadequate healthcare access, increases vulnerability to CL. Key hotspots and seasonal patterns reveal shifting trends in disease incidence, necessitating adaptable public health interventions. Addressing environmental management, such as waste disposal and vegetation control, alongside enhancing community awareness and healthcare accessibility, is vital for effective disease mitigation. These insights not only inform local health strategies but also contribute to the broader understanding of CL dynamics in Pakistan, emphasizing the need for targeted approaches that consider the unique characteristics of affected regions. Enhanced collaboration between health authorities, communities, and environmental agencies will be essential to reduce CL transmission and improve health outcomes in Chitral.

Author contributions

F.K. conceptualized the project and developed the methodology. B.U. and S.S. conducted a formal analysis and drafted the original writing. contributed to the methodology. S.Y. and S.S. conducted investigations and provided resources to visualize the data. M.U contributed to the reviewing and editing of the writing.

Acknowledgment

None declared.

Competing financial interests

The authors have no conflict of interest.

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