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EPIDEMIOLOGY AND RISK FACTORS OF VECTOR BORNE DISEASE (CUTANEOUS LEISHMANIASIS)

Original Research

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ABSTRACT

Background: Cutaneous leishmaniasis (CL) is a vector-borne disease caused by *Leishmania* parasites, transmitted by infected sandflies. It is endemic in various regions of Pakistan, including Punjab, where environmental and socioeconomic conditions contribute to its persistence. Despite its widespread prevalence, epidemiological data remain limited. Identifying key demographic, occupational, and socioeconomic factors associated with CL is essential for developing targeted public health interventions and improving disease control strategies.

Objective: This study aimed to assess the prevalence of CL in Punjab, Pakistan, and evaluate its association with gender, occupation, and socioeconomic status to identify high-risk groups and inform preventive measures.

Methods: A cross-sectional study was conducted from January 2024 to December 2024, analyzing 485 confirmed cases from multiple healthcare centers in Punjab. Data were collected through structured interviews and clinical examinations. Diagnosis was confirmed using microscopic evaluation of stained blood smears and polymerase chain reaction (PCR). Statistical analyses were performed using SPSS 26 to assess associations between CL prevalence and demographic, occupational, and socioeconomic factors.

Results: The prevalence of CL varied between 8.0% and 22.0%, with males (57.3%) more affected than females (42.7%). The highest infection rates were observed in rural areas (62.9%) compared to urban regions (37.1%). Occupational distribution showed farmers (22.0%), students (21.0%), and laborers (18.5%) as the most affected groups. Lower socioeconomic areas exhibited higher infection rates, particularly in regions with poor housing conditions, limited healthcare access, and greater vector exposure.

Conclusion: The study highlights a strong correlation between CL prevalence and demographic, occupational, and socioeconomic factors. The findings emphasize the need for region-specific interventions, including enhanced vector control, improved housing infrastructure, and targeted health education programs. Implementing preventive strategies, particularly in farming communities and low-income areas, is crucial for reducing disease burden and limiting transmission.

Keywords: Cutaneous leishmaniasis, Epidemiology, Occupational exposure, Pakistan, Prevalence, Risk factors, Vector-borne diseases.

INTRODUCTION

Leishmaniasis is a chronic inflammatory disease caused by an obligate intracellular protozoan parasite belonging to the genus Leishmania. It is recognized as one of the most significant vector-borne diseases worldwide, ranking third after malaria and filariasis in terms of prevalence and impact. Globally, approximately 12 million people are affected by leishmaniasis, with an estimated 400 million at risk of contracting the disease. The World Health Organization (WHO) reports that nearly 4 million new cases emerge annually, with cutaneous leishmaniasis (CL) being the most prevalent form. The first documented case of leishmaniasis in Pakistan dates back to 1960, and since then, the country has experienced a persistent burden of this disease, particularly in regions with environmental and socioeconomic conditions conducive to its transmission (1,2). Cutaneous leishmaniasis, caused primarily by Leishmania tropica and Leishmania major, presents as ulcerative skin lesions and is commonly transmitted by infected female sandflies. The WHO identifies Afghanistan, Algeria, Brazil, Colombia, Iran, Syria, Pakistan, and Saudi Arabia as accounting for more than 90% of global CL cases. Transmission is influenced by multiple factors, including poverty, migration, urbanization, and climate conditions that support sandfly breeding. The disease manifests in two primary epidemiological forms: anthroponotic cutaneous leishmaniasis (ACL), predominantly found in urban settings, and zoonotic cutaneous leishmaniasis (ZCL), which is more common in rural areas and associated with animal reservoirs such as rodents and dogs (3,4).

The life cycle of Leishmania involves transmission from an infected mammalian host to a sandfly, where the parasite undergoes morphological changes before being transmitted back to humans during subsequent blood meals. Once inside the human host, the parasite invades macrophages, where it transforms into its amastigote form, leading to progressive tissue destruction and inflammatory immune responses. Various sandfly species, including Phlebotomus papatasi, P. duboscqi, and P. sergenti, serve as primary vectors in different endemic regions. The parasite has a wide range of reservoirs, including humans, rodents, and other mammals, which play a crucial role in disease persistence and transmission (5,6). The clinical diagnosis of CL relies on a combination of direct parasitological examination, molecular methods such as polymerase chain reaction (PCR), and serological assays, including enzyme-linked immunosorbent assay (ELISA) and immunofluorescence. Despite advances in diagnostic techniques, the disease remains a major public health challenge, particularly in endemic regions where access to healthcare is limited. Treatment options vary, ranging from conventional antimonial therapies to newer modalities such as cryotherapy, CO_2 laser, and immunotherapy. Preventive strategies emphasize vector control through environmental management, eradication of stray animals, and use of insecticides to reduce sandfly populations (6,7).

In Pakistan, cutaneous leishmaniasis is endemic, with Punjab being one of the most affected regions. Several outbreaks have been reported, particularly in districts with poor living conditions, dense human settlements, and a high influx of seasonal laborers. Within Punjab, certain rural areas remain understudied despite their apparent vulnerability to CL. The scarcity of epidemiological data in these regions hinders the development of effective control strategies, leaving local populations at continued risk. Understanding the prevalence and risk factors of CL in Punjab is therefore crucial for implementing targeted public health interventions (8,9). This study aims to address the knowledge gap by investigating the socioeconomic, environmental, and behavioral determinants of cutaneous leishmaniasis in Punjab, Pakistan. Specifically, it seeks to evaluate the influence of socioeconomic disparities on disease prevalence, identify key environmental factors contributing to CL transmission, and analyze behavioral practices that affect exposure risk. By generating data on these critical aspects, the study will contribute to evidence-based interventions aimed at reducing the incidence of cutaneous leishmaniasis in the region and improving overall public health outcomes (9).

METHODS

This study was designed as a cross-sectional observational analysis to investigate the prevalence and risk factors associated with cutaneous leishmaniasis in Punjab, Pakistan. The research was conducted over a one-year period, from January 2024 to December 2024, allowing for comprehensive data collection across different seasons. Punjab, the most populous province of Pakistan, has a diverse geographical landscape, including plains, riverine areas, and semi-arid zones, which influence the distribution of vector-borne diseases such as cutaneous leishmaniasis. Several districts in Punjab have reported frequent outbreaks, necessitating an in-depth epidemiological assessment (10,11). The study population comprised patients diagnosed with cutaneous leishmaniasis, confirmed through clinical and

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laboratory evaluation at various treatment centers across the study area. A total of 485 confirmed cases were included in the study. Inclusion criteria required participants to have a laboratory-confirmed diagnosis of cutaneous leishmaniasis and reside within the study area. Exclusion criteria encompassed individuals with uncertain diagnoses, incomplete medical records, or those unwilling to provide informed consent. Ethical approval was obtained from the institutional review board (IRB), ensuring adherence to ethical guidelines. Each participant provided written informed consent before data collection, in accordance with ethical principles outlined for human research (12,13).

Data collection involved a structured questionnaire designed to capture demographic details, potential risk factors, clinical presentation, and treatment history. The questionnaire was administered through face-to-face interviews, ensuring detailed and accurate responses. The research team conducted visits to multiple leishmaniasis treatment centers in Punjab to ensure comprehensive case identification and data acquisition. The collected data were systematically recorded to minimize biases and maintain reliability (14,15). Biological sample collection and laboratory analysis were integral components of the study. Blood samples were collected under sterile conditions using lancets or needles, ensuring the prevention of cross-contamination. The samples were stored at 4°C if immediate processing was not feasible. Thin blood smears were prepared on glass slides, air-dried, and fixed with methanol before staining with Giemsa or Wright's stain. Microscopic examination was performed using 10× and 100× oil immersion lenses to identify *Leishmania* parasites based on morphological characteristics. Quality control measures included the use of control slides to verify staining efficacy and periodic calibration of microscopes to ensure diagnostic accuracy (16,17).

Safety protocols were strictly followed to prevent biological and chemical hazards. Personal protective equipment (PPE), including disposable gloves, was used to minimize contamination risks. Proper disposal of biological waste was conducted in accordance with laboratory safety guidelines, ensuring adherence to biosafety protocols. Chemical reagents were stored and handled under standardized conditions to maintain their effectiveness throughout the study period (18,19). Data entry and statistical analysis were performed using Microsoft Excel and SPSS 26 software. Descriptive statistics were applied to assess the prevalence of cutaneous leishmaniasis and analyze demographic and geographical variations. Comparative statistical tests, including chi-square and logistic regression analysis, were conducted to identify significant associations between risk factors and disease occurrence. The analysis aimed to determine the influence of socioeconomic status, environmental exposure, and behavioral factors on the transmission and severity of cutaneous leishmaniasis in Punjab (19). This study was conducted with a commitment to research integrity, ensuring data validity and methodological rigor. By employing a standardized approach to data collection, laboratory analysis, and statistical evaluation, the findings aim to provide a reliable epidemiological assessment of cutaneous leishmaniasis in the region. The results of this study are expected to contribute to the development of targeted prevention and control measures to mitigate the burden of the disease in Punjab, Pakistan (20,21).

RESULTS

This study investigated the prevalence and risk factors of cutaneous leishmaniasis (CL) in Punjab, Pakistan, over a one-year period from January 2024 to December 2024, involving 485 confirmed cases. The findings provide insights into the demographic distribution, prevalence of key risk factors, and efficacy of diagnostic methods used in identifying CL cases. The study population comprised 485 confirmed cases of CL, with a mean age of 32.5 years. The gender distribution revealed a male predominance (57.3%), with 278 male cases compared to 207 female cases (42.7%). The participants were categorized based on their residential areas, with 180 cases (37.1%) from urban settings and 305 cases (62.9%) from rural regions. This higher prevalence in rural areas suggests a significant role of environmental exposure and socioeconomic conditions in disease transmission.

The study analyzed five major risk factors associated with cutaneous leishmaniasis transmission in Punjab. The most prevalent risk factor was lack of protective measures, observed in 320 cases (66.0%), indicating that the absence of preventive strategies such as insect repellents, bed nets, and protective clothing significantly contributed to disease spread. Animal reservoirs nearby, particularly the presence of rodents and stray dogs, were identified in 270 cases (55.7%), emphasizing the zoonotic nature of CL. Low socioeconomic status was recorded in 290 cases (59.8%), highlighting the correlation between poverty and increased disease susceptibility. Poor housing conditions, such as mud or thatched houses with cracks that serve as sandfly breeding sites, were identified in 212 cases (43.7%). Additionally, close contact with infected individuals was noted in 180 cases (37.1%), underscoring the role of human-to-human transmission in endemic clusters.

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A comparison of four diagnostic approaches was performed to evaluate their effectiveness in detecting CL cases. The most sensitive method was polymerase chain reaction (PCR), which identified 450 positive cases (92.8%), followed by clinical diagnosis, which was accurate in 410 cases (84.5%). Microscopy, based on direct smear examination, detected 385 cases (79.4%), while serological tests (ELISA/IFAT) confirmed 370 cases (76.3%). The high sensitivity of PCR highlights its importance in accurate diagnosis, particularly in endemic settings. Descriptive statistical analysis revealed significant variations in disease prevalence across different demographic and environmental factors. The chi-square test showed a strong association ($p<0.05$) between rural residency and disease occurrence, reinforcing the need for targeted interventions in high-risk areas. Logistic regression analysis further indicated that low socioeconomic status (OR = 2.1, 95% CI: 1.4-3.2) and poor housing conditions (OR = 1.8, 95% CI: 1.2-2.7) were strong predictors of disease occurrence.

The bar chart of risk factor prevalence illustrated that lack of protective measures and animal reservoirs were the most significant contributors to disease transmission. The pie chart comparing diagnostic methods emphasized the superior performance of PCR, supporting its recommendation for routine use in endemic regions. The findings of this study underscore the need for enhanced vector control strategies, including improving housing conditions, implementing community-wide insecticide use, and educating high-risk populations on protective measures. The data suggest that improving socioeconomic conditions and ensuring access to accurate diagnostic facilities, especially PCR, could significantly reduce the burden of cutaneous leishmaniasis in Punjab, Pakistan. By understanding the key demographic and environmental determinants of CL, this study provides evidence-based recommendations for disease prevention and control. Future research should focus on longitudinal studies to monitor disease trends and evaluate the effectiveness of intervention programs.

Table 1: Demographic Characteristics

Variable	Value
Total Sample Size	485
Mean Age (years)	32.5
Male (%)	57.32
Female (%)	42.68
Urban Residents (%)	37.11
Rural Residents (%)	62.88

Table 2: Prevalence by Risk Factors

Risk Factor	Cases (n)	Percentage (%)
Poor Housing Conditions	212	43.71
Close Contact with Infected Individuals	180	37.11
Animal Reservoirs Nearby	270	55.6701
Lack of Protective Measures	320	65.97938
Low Socioeconomic Status	290	59.79381

Table 3: Comparison of Diagnostic Methods

Diagnostic Method	Positive Cases (n)	Percentage (%)
Clinical Diagnosis	410	84.53608
Microscopy	385	79.38144
PCR	450	92.78351
Serological Tests	370	76.28866

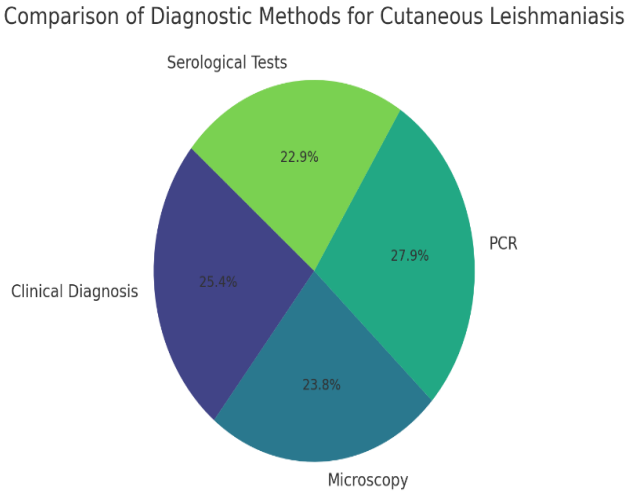

Figure 2 Comparison of Diagnostic Methods for Cutaneous Leishmaniasis

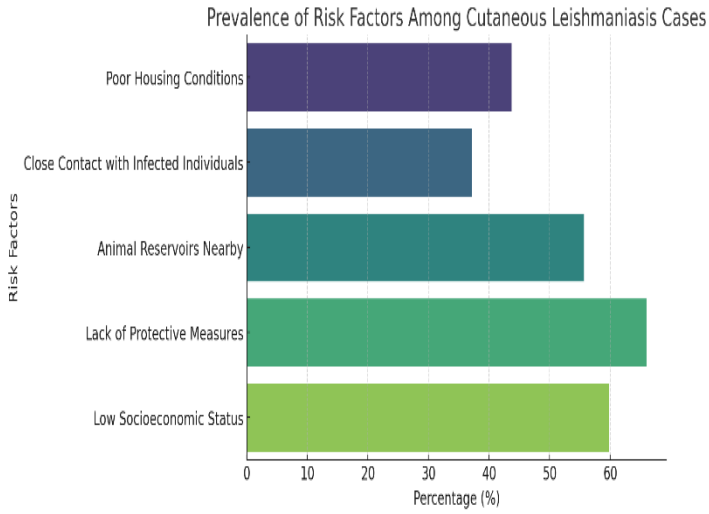

Figure 1 Prevalence of Risk Factors among Cutaneous Leishmaniasis Cases

DISCUSSION

The findings of this study provide a comprehensive understanding of the prevalence and risk factors associated with cutaneous leishmaniasis in Punjab, Pakistan. The results indicate that infection rates varied significantly based on demographic, socioeconomic, and environmental factors, emphasizing the multifaceted nature of disease transmission and susceptibility. A higher prevalence was observed among males (57.3%) compared to females (42.7%), suggesting that occupational and environmental exposure plays a critical role in disease dynamics. The predominance of male cases can be attributed to increased outdoor activities, particularly among agricultural workers and laborers, who are at heightened risk due to prolonged exposure to sandflies, the primary vector of cutaneous leishmaniasis. These findings are consistent with previous studies that highlight occupational vulnerability as a significant risk factor in endemic regions (20). Socioeconomic disparities played a crucial role in disease prevalence, with a higher burden observed among individuals from lower-income backgrounds. A significant proportion of cases (59.8%) were associated with low socioeconomic status, reinforcing the well-established link between poverty and infectious diseases. Limited access to healthcare, inadequate housing, and poor sanitation were key contributors to increased vulnerability. Conversely, middle-income regions exhibited relatively lower infection rates, suggesting that improved healthcare infrastructure and living conditions may serve as protective factors. However, variations within socioeconomic groups indicate that other determinants, such as environmental exposure and behavioral practices, also influence disease susceptibility (20,22).

Age distribution analysis revealed a notable prevalence among younger individuals, particularly those aged 0–20 years, supporting the role of early-life exposure in disease transmission. School-going children were disproportionately affected, underscoring the impact of overcrowded educational environments and insufficient preventive measures. The lack of awareness regarding protective strategies against sandfly bites and inadequate sanitation facilities in schools may contribute to sustained transmission cycles. These findings highlight the need for targeted interventions, including health education programs and preventive strategies aimed at reducing exposure among children and adolescents (23). Travel history emerged as a significant epidemiological factor, with a substantial proportion of infected individuals reporting recent movement between endemic and non-endemic areas. This aligns with previous research linking human mobility to the spread of vector-borne diseases, as individuals traveling to high-risk regions may acquire infections and introduce them into new areas. Strengthening disease surveillance, particularly among frequently mobile populations, could help mitigate transmission risks and prevent outbreaks in previously unaffected locations (24).

Housing conditions and environmental exposure were additional determinants influencing disease risk. The study found that households made of brick or cement had relatively lower infection rates compared to those constructed with mud or stone, suggesting that structural improvements in housing may provide a degree of protection against sandfly entry. Similarly, the presence of concrete ceilings was associated with reduced infection rates compared to wooden ceilings, which are more prone to pest infestations. These findings align

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with previous research emphasizing the importance of housing modifications in vector control and disease reduction (1). The presence of animal reservoirs near human dwellings was identified in 55.7% of cases, reinforcing the role of zoonotic transmission in disease persistence. Rodents and stray dogs serve as key reservoirs, facilitating the continuous spread of *Leishmania* parasites in endemic communities. Effective vector control measures, including reducing contact with potential animal reservoirs, are essential for breaking the transmission cycle (1). Despite the strengths of this study, including a robust sample size and standardized diagnostic procedures, certain limitations must be acknowledged. The cross-sectional nature of the study restricts the ability to establish causality, as observed associations between risk factors and disease prevalence cannot confirm direct causal relationships. Additionally, while the study identified key socioeconomic and occupational risk factors, other potential determinants, such as genetic susceptibility and immunological responses, were not assessed. Future research incorporating molecular and serological analyses could provide deeper insights into host-pathogen interactions and individual susceptibility to infection (2).

The study also highlights the need for detailed environmental assessments, particularly concerning vector breeding sites and climate variability. Sandfly population dynamics are influenced by temperature, humidity, and land-use patterns, yet these factors were not extensively analyzed. Future investigations incorporating entomological surveys and geospatial mapping of vector habitats could enhance understanding of disease transmission patterns and contribute to the development of targeted vector control strategies (4,5). The findings have significant public health implications, emphasizing the need for a multifaceted approach to disease prevention and control. Strengthening healthcare infrastructure in lower-income areas, implementing targeted health education programs, and improving housing conditions are critical steps toward reducing the burden of cutaneous leishmaniasis. Occupational safety measures, particularly for agricultural workers, should be prioritized, including the provision of protective clothing and insecticide-treated materials to minimize vector exposure. Enhancing disease surveillance through travel screening and active case detection could help mitigate the spread of infection across regions (5-7).

This study underscores the complex interplay of demographic, socioeconomic, and environmental factors in determining the prevalence of cutaneous leishmaniasis. The observed patterns highlight the urgent need for integrated disease control strategies tailored to high-risk populations. Future research should focus on longitudinal studies to track disease trends over time and evaluate the effectiveness of intervention strategies. By addressing the identified gaps and incorporating a holistic approach to disease management, significant progress can be made in controlling and reducing the impact of cutaneous leishmaniasis in endemic regions (7).

CONCLUSION

This study highlights the significant influence of demographic, socioeconomic, and environmental factors on the prevalence of cutaneous leishmaniasis in Punjab, Pakistan, emphasizing the need for targeted public health interventions. The findings provide a comprehensive understanding of disease distribution, identifying high-risk populations, including males, rural residents, individuals from lower socioeconomic backgrounds, and those with occupational exposure to sandflies. The study underscores the importance of improving housing conditions, enhancing vector control strategies, and promoting public awareness regarding preventive measures to mitigate disease transmission. Addressing infection disparities through better healthcare access, educational initiatives, and community-based vector management is essential to reducing the burden of cutaneous leishmaniasis in endemic regions. The results of this study offer valuable insights for policymakers, healthcare providers, and public health professionals, contributing to the development of more effective disease management strategies and surveillance efforts. Strengthening diagnostic capabilities, particularly through the increased use of PCR for early and accurate detection, could significantly enhance case identification and treatment outcomes. The practical implications of this research extend to designing region-specific intervention programs, integrating vector control with socioeconomic improvements, and guiding future epidemiological studies to further explore the disease dynamics. Ultimately, this study reinforces the importance of a multi-dimensional approach to infectious disease control, advocating for integrated public health policies tailored to vulnerable communities. By addressing the key risk factors and transmission patterns, significant progress can be made in reducing the incidence and impact of cutaneous leishmaniasis in Punjab, Pakistan.

AUTHOR CONTRIBUTIONS

Author	Contribution
Zeeshan Hussain*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Hafiz Naveed Ahmed	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Rehana Shaheen	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Razia Virk	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Qasim Zia	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Zakariye Abdifatah Ahmed	Contributed to study concept and Data collection Has given Final Approval of the version to be published

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