Medical Laboratory Journal
Online ISSN: 2538-4449
Golestan University of Medical Sciences

Epidemiological and geographical features of cutaneous leishmaniasis in Southwestern Khuzestan

Kazem Alizadeh-Barzian [1], Mohammad Amin Ghatee [2,3], Mehdi Jamshidi [1], Mohamad Sabaghan [4], Abolhasan Difrakhsh [1], Zahra Nikkhooy [4], Masoud Parash [5], Ali Jamshidi [4]*

1. Department of Public Health, Behbahan Faculty of Medical Sciences, Behbahan, Iran
2. Professor Alborzi Clinical Microbiology Research Center, Shiraz University of Medical Sciences, Shiraz, Iran
3. Cellular and Molecular Research Center, Yasuj University of Medical Sciences, Yasuj, Iran
4. Department of Basic Medical Sciences, Behbahan Faculty of Medical Sciences, Behbahan, Iran
5. Department of Clinical Sciences, Behbahan Faculty of Medical Sciences, Behbahan, Iran

* Correspondence: Ali Jamshidi. Department of Basic Medical Sciences, Behbahan Faculty of Medical Sciences, Behbahan, Iran.
Tel: +989175413025; Email: ajamshidi@behums.ac.ir

Abstract

Background: Cutaneous leishmaniasis (CL) is a protozoan infection caused by a flagellated parasite complex known as *Leishmania* spp. Iran is an endemic area for CL. The present study aimed to investigate the epidemiological factors and geographical distribution of CL in Southwestern Khuzestan using the GIS method.

Methods: In this cross-sectional study, epidemiological and demographic data from 787 individuals affected by CL in Behbahan County between 2002 and 2021 were collected. Patient locations were plotted on a point shapefile of villages, towns, and cities in Behbahan County, and geographic data were analyzed using ArcGIS version 10.

Results: Among the 787 studied cases, 512 (65%) were male. The disease was most prevalent among individuals aged 21-30 years. Lesions appeared in various regions of the body, with 41% of cases involving the hands. The highest annual incidence rate was recorded in 2009, at approximately 40 cases per 100,000 population, whereas the lowest incidence rate occurred in 2002, at 5.8 per 100,000 population. Noticeable variations in disease prevalence were identified among non-Iranian individuals, rural populations (Including pastoral and peri-urban areas), males, and younger individuals. Geographic Information System (GIS) analysis indicated that the most affected areas were located in the central region (Behbahan or Markazi area) and the southern region (Zeydoon) of the mapped topography.

Conclusion: The findings highlight the need to implement effective prevention and control measures to reduce the burden of CL in Behbahan County. These measures should include targeted health education campaigns and vector control strategies, with particular focus on regions identified as high-prevalence areas through GIS topographic analysis.

Article Type: Research Article

Article History

Received: 29 July 2024
Received in revised form: 10 April 2025
Accepted: 8 June 2025
Available online: 19 June 2026
DOI: 10.29252/mlj.20.3.18

Keywords

Cutaneous Leishmaniasis
Medical Topography
Geographic Information Systems
Epidemiology
Iran

Introduction

Leishmaniasis is a zoonotic disease transmitted by sandflies (*Phlebotomus* spp.) and caused by a group of protozoan parasites known as *Leishmania* spp. It manifests in several forms, including cutaneous (CL), mucocutaneous (MCL), and visceral (VL) leishmaniasis (1,2). With approximately 1.5 million new cases annually, this widespread disease poses a risk in more than 100 countries (3). Cutaneous leishmaniasis is particularly prevalent in South America, the Middle East, and North Africa (2,4), with *L. tropica* and *L. major* being the primary etiological agents in the Old World, although other species, such as *L. aethiopica*, *L. infantum*, and *L. donovani*, have been reported globally as causes of CL lesions (5). The epidemiology of leishmaniasis is influenced by interactions among the parasite, vector, host, and environment. In Iran, where an estimated 20,000 cases occur annually, the main species responsible for CL are *L. major* and *L. tropica* (6,7). Zoonotic cutaneous leishmaniasis (ZCL), caused by *L. major*, is primarily transmitted to humans in Iran (8) through *Phlebotomus* papatasi sandflies, while anthroponotic cutaneous leishmaniasis (ACL) (9,10), caused by *L. tropica*, is transmitted between humans through *Ph. sergenti* sandflies, which have also been sporadically identified in dogs (11). The geographic distribution of CL in Iran is extensive (12), with *L. major* predominating in the southwest, west, central, and northeast regions, whereas *L. tropica* is commonly found in the southeast and east, as well as in major cities such as Shiraz, Mashhad, and Tehran (13). Geographic information systems (GIS) have facilitated the investigation of the spatial epidemiology of vector-borne diseases. Several GIS-based studies have mapped the distribution of leishmaniasis in Iran (14-17). Khuzestan Province, located in southwestern Iran, is considered one of the country's most important foci of zoonotic cutaneous leishmaniasis (ZCL), and Behbahan County is one of its important disease foci (14). The present study aimed to investigate the epidemiological factors and geographical distribution of CL in Southwestern Khuzestan using the GIS method from 2002 to 2021.

Methods

Study area

Behbahan (Figure 1) is one of the twenty-seven counties of Khuzestan Province in southwestern Iran (18). The capital of the county is Behbahan City. The county is subdivided into three districts: Central, Tashan, and Zeydun. It also consists of four cities: Behbahan, Mansuriyeh, Tashan, and Sardasht (19). Behbahan has a land area of approximately 3,195 km^2 and is located in the southeast of Khuzestan Province at approximately 30° 35′ 45′′ N and 50° 14′ 30′′ E. The population of this county is estimated at 300,000 people (20). Behbahan has a hot semi-arid climate, with extremely hot and dry summers and mild winters that may occasionally be accompanied by heavy rainfall. The average temperature ranges from 42°C during the summer to 35°C, 25°C, and 13°C during autumn, spring, and winter, respectively.

Figure 1. Location of Behbahan county in southwestern Iran

Patient and geographical data collection

Data from all CL patients, including epidemiological and demographic information, previously confirmed through microscopic slides and molecular methods in both public and private sectors between 2002 and 2021, were obtained from the Behbahan Health Center. This cross-sectional, descriptive study analyzed demographic and clinical information, including patients' age, gender, occupation, place of residence, month of illness onset, workplace, illness duration, affected counties, nationality, type of wound tissue, lesion morphology, number and size of ulcers, and administered treatments. Statistical analyses were conducted using SPSS software version 21. For spatial analysis, patient locations were mapped using a point shapefile of villages, towns, and cities in Behbahan County. The mapping process was performed using ArcGIS software version 10.5 (http://www.esri.com/arcgis), with the shapefile polygon layer of Behbahan County purchased online from https://rsgisc.com/.

Results

Between 2002 and 2021, a total of 708 cases of CL were documented in Behbahan County, with 65% (n=512) of patients being male and 35% (n=275) female. Urban residents constituted 55% (n=433) of cases, while 45% (n=354) were from rural areas. The highest prevalence was observed among young adults aged 21-30 years, accounting for 29% (n=226) of cases, whereas the lowest prevalence, 1% (n=9), was found among elderly patients aged over 70 years. Among patients, 25-year-olds represented the peak prevalence rate of 26.6%. The mean age of male and female patients was 26.1 and 27.3 years, respectively, with 68% of all cases occurring in individuals under the age of 30 (Table 1). Lesions were distributed across various body regions, with 41% of patients experiencing lesions on their hands, 35% on their feet, 18% on their face, 4% on their trunk, and 2% on their neck and head. Approximately 54% of patients presented with a single lesion, and the highest number of lesions observed in one patient was 25. In total, 927 lesions were reported among all cases (Table 2). Regarding occupation, students represented the largest affected group, accounting for 21% (n=162) of cases (Table 3). A majority of wounds (61.8%, n=606) were larger than 1 cm in diameter. The study further categorized skin lesions as non-secretory, erythematous, or dry in 65% of cases, while 33% were secretory, and 2% exhibited other wound characteristics (Table 4). The year 2009 recorded the highest number of CL cases (n=75), with the lowest number reported in 2002 (n=10). Seasonally, January (Winter) had the highest number of cases (n=125), whereas July (Summer) accounted for the lowest number (n=23) (Table 5). Annual incidence rates varied from 40 per 100,000 in 2009 to 5.8 per 100,000 in 2002 (Table 6). Regarding treatment approaches, 82% (n=645) of patients received intralesional Glucantime, 13% (n=102) were treated systemically with Glucantime, 4% (n=31) underwent a combination of cryotherapy and Glucantime, and 1% (n=8) received cryotherapy alone. Geographic Information System (GIS) analysis revealed that the central areas (Behbahan or Markazi part) and southern regions (Zeydoon) of Behbahan County were the most affected by CL, as shown in Figure 2.

Table 1. Prevalence of CL among age groups in Behbahan county during 2002-2021

Age groups (y-o*)	**1-10**	**11-20**	**21-30**	**31-40**	**41-50**	**51-60**	**61-70**	**> 70**	Total
Frequency	140	165	226	98	70	56	23	9	787
Percent	18	21	29	12	9	7	3	1	100

(*y-o = Years old)

Table 2. Prevalence of CL according to lesion site in Behbahan county during 2002-2021

Place of lesions	**Hands**	**Feet**	**Trunk**	**Neck and Head**	**Face**	Total
Frequency	375	327	41	22	162	927
Percent	41	35	4	2	18	100

Table 3. Prevalence of CL according to occupation in Behbahan county during 2002-2021

Occupation	**Shepherd**	**Collegian**	**Soldier**	**Military**	**Staff**	**Driver**	**Freelance job**	**Farmer**	**Unemployed Person**	**Worker**	**Child**	**Housewife**	**Student**	**Other**	**Total**
Frequency	8	10	17	24	31	32	49	52	33	79	86	128	162	76	787
Percent	0.2	1	2.1	3.1	8.3	3.9	6	7	4	10.4	1	16	21	10	100

Table 4. Prevalence of CL according to lesion size in Behbahan county during 2002-2021

Size of Lesions	**≤ 0.5 cm**	**1 cm**	**2 cm**	**3 cm**	**4 cm**	**5 cm**	**6 cm**	**≥ 7 cm**	Total
Frequency	355	172	185	98	75	18	19	5	927
Percent	38.2	18.5	20	10.5	8.1	1.9	2	0.5	100

Table 5. Prevalence of CL according to years and months in Behbahan county during 2002-2021

Based on month	April		May		June		July		August		September		October		November		December		January	February	March
Frequency	51		54		57		23		36		47		52		62		102		125	109	69
Percent	6.5		6.9		7.2		2.9		4.6		6		6.6		7.9		13		15.9	13.6	8.8
Based on years	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	
Frequency	10	50	27	37	39	39	64	75	55	64	23	21	42	37	28	29	31	26	29	61	
Percent	1.3	6.3	3.4	4.7	4.8	4.8	8.1	9.5	7	8.1	2.9	2.7	5.3	4.7	3.5	3.7	3.8	3.3	3.7	7.7	

Table 6. Annual incidence rate of cutaneous leishmaniasis (CL) per 100,000 population in Behbahan county from 2002 to 2021

The annual incidence rate																					
Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Average
Population	172561	174311	176735	180531	182345	184521	186641	187650	189583	19045	196511	203412	211582	212550	213697	214285	214551	215289	215432	215536	197038
Frequency	10	50	27	37	39	39	64	75	55	64	23	21	42	37	28	29	31	26	29	61	39.3
Incidence	5.8	28.7	15.3	20.5	21.4	21.1	34.3	40	29	33.2	11.7	10.3	19.9	17.4	13.1	13.5	14.4	12.1	13.5	28.3	20

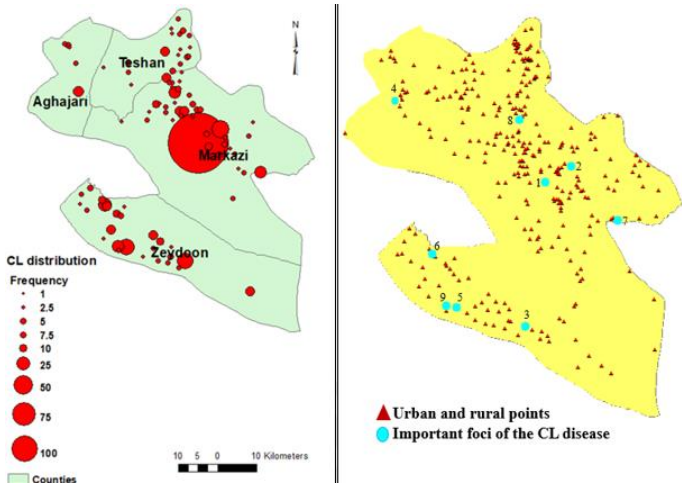

Figure 2. Left (CL distribution map) and right (Nine important disease foci). Based on the GIS maps, the most infected areas were the central (Behbahan or Markazi part) and southern (Zeydoon) regions. Behbahan City (Point 1 on the right map, n=312 cases) was identified as the main focus of CL. Other important foci, with more than 10 reported cases, are shown on the map as follows: point 2: Mansuriyeh (n=25), 3: Sardasht (n=22), 4: Aghajari (n=21), 5: Darunak (n=21), 6: Longir vosta (n=16), 7: KheirAbad, 8: Dudangeh bozorg, and 9: Julahi (n=11).

Discussion

Leishmaniasis is classified by the World Health Organization (WHO) as one of the neglected tropical diseases (NTDs) (21). CL is an important health problem of considerable epidemiological importance in southwestern Iran and requires effective prevention and control measures (22). This study is the first to survey the distribution pattern of cutaneous leishmaniasis in Behbahan County. The findings revealed that although the disease affected individuals of all ages, most patients were young adults between 21 and 30 years of age. This may be explained by the migration of young people as a workforce to more populated villages and cities, as well as their greater likelihood of exposure to sandfly bites due to occupational activities and socioeconomic conditions.

In some studies, the prevalence of CL was higher in children under 10 years old (20-22), whereas another study reported predominance in the 30-39-year age group (23). These findings are not consistent with the results of the present study. Similar to most studies conducted in Iran (23-25), the present study found that the disease was more prevalent among men and in urban areas (Around cities). Because of men's occupations and outdoor activities, clothing style, use of short-sleeved clothing, and migration to different cities for work, especially in endemic areas, disease prevalence is higher among men. Unlike the present study, some studies showed that CL prevalence was higher among women and rural populations. In their study in Lamerd County, Jafarnejad et al. stated that the higher prevalence of the disease among women may be due to the employment of male family members in Persian Gulf countries and the lack of agriculture, which results in men spending more time away from outdoor spaces in the local area (26-28).

Similar to some previous studies, the results of this study revealed that most bites occurred on the hands (29-31). In some studies, most bites were reported on both the hands and feet (26), in others on the face, and in some on both the hands and face (27). The hand is one of the uncovered parts of the body and has more direct contact with the environment than other body regions. In addition, the mouthparts of sandflies are shorter than those of some mosquitoes, such as Anopheles mosquitoes, making it difficult for them to bite sites covered by clothing.

The findings of our study indicate that CL had the highest prevalence during the winter months. This pattern may be linked to Behbahan's tropical climate, where the maturation and development of parasites in mosquito vectors occur more rapidly than in regions with temperate climates. Moreover, zoonotic cutaneous leishmaniasis (ZCL), caused by *Leishmania major*, represents the predominant form of CL in Khuzestan Province, including Behbahan County. The average interval between a mosquito bite and the emergence of ZCL as a papule is approximately two weeks (32).

In the study by Namrodi et al. in 2016 in Isfahan Province, most cases of the disease were reported in the fall season (33), whereas in another study conducted in the same province by Barouti-Ardestani et al. in 2020, most cases were reported in the summer season (25). The main reason for this difference is variation in climatic conditions, environment, ecology, and vector behavior across different provinces of the country. In simpler terms, variations in geographical climates result

in different transmission patterns and varying effects of meteorological variables on cutaneous leishmaniasis. It is important to note that although climate change can influence the transmission of leishmaniasis, it is not the only determining factor. Socioeconomic factors, urbanization, and healthcare infrastructure also play crucial roles in the prevalence and control of the disease (34,35).

The results of the present study showed that the incidence rate varied between 10 and 75 people per 100,000 population from 2002 to 2021 and has decreased over the last 10 years. Reasons for the reduction in disease incidence include improved health conditions, environmental improvements, climate change, drought, and the design and implementation of an annual action plan to control rodents in key disease areas. In addition, public and personal health education, along with personal protection measures, has contributed to the decline in Behbahan County. A decrease in disease incidence in most regions of Iran has been reported in various studies. Possible reasons include improved healthcare infrastructure, vector control measures, public awareness and education, urbanization and changes in human behavior, and climate change effects (25,31,36).

Geographic Information System (GIS) analysis indicated that the central region (Behbahan) and the southern region (Zeydoon) of the topographic map had the highest prevalence of CL. Factors contributing to the elevated prevalence in these areas may include extensive agricultural lands cultivating crops such as corn, wheat, and barley, which promote the proliferation of rodent populations. In addition, the combination of humidity and temperature in these regions provides optimal conditions for the breeding and development of ground mosquitoes within rodent nests. Azimi et al. conducted a study in Khuzestan Province using GIS topographic mapping to identify regions with higher rates of cutaneous leishmaniasis (CL). Their findings revealed that the western and southern parts of the province exhibited elevated infection rates, which were likely influenced by high temperature and humidity levels (37). Similarly, research by Davoodi et al. on the geographical distribution of CL in Fars Province revealed that anthroponotic cutaneous leishmaniasis (ACL) was detected exclusively in Shiraz City, whereas zoonotic cutaneous leishmaniasis (ZCL) was prevalent in both Shiraz and most other counties within the province. Notably, the highest concentration of CL cases was reported in district 8 of Shiraz municipality, underscoring the need for targeted interventions in this area (9). In addition, Khademvatan et al. examined the spatial distribution of leishmaniasis in southwestern Iran, reporting significant prevalence in the central and western regions of Khuzestan Province. Their study also found that urban areas had higher infection rates than rural regions (38).

Conclusion

Although the incidence rate of cutaneous leishmaniasis in Behbahan City decreased from 2002 to 2021 and important control and preventive measures have been implemented, this disease remains an active public health problem because of increases observed in some years. The results suggest that effective prevention and control measures, including health education campaigns and vector control strategies, especially in areas with high prevalence according to GIS topography, are necessary to reduce the burden of CL in Behbahan County.

Acknowledgement

We would like to express our sincere gratitude to all patients who participated in this study and generously provided their clinical and demographic information. We also thank the staff at the Behbahan County Health Center for their support in data collection. We are grateful to the Behbahan Faculty of Medical Sciences for providing the necessary resources and financial support. Finally, we would like to acknowledge the support and guidance provided by our colleagues and collaborators throughout this project.

Funding Sources

Research funds from the Behbahan Faculty of Medical Sciences and Health Services were used to conduct this research.

Ethical Statement

This article was supported and approved by the Ethics Committee of the Behbahan Faculty of Medical Sciences (Code: IR.BHN.REC.1401.012). Patient data were de-identified to protect the privacy and confidentiality of the participants. In addition, the study was conducted with utmost respect for the cultural norms and traditions of the participants. Any potential conflicts of interest were disclosed and managed appropriately. The results of the study will be disseminated in a manner that respects the dignity and privacy of the participants and without identifying any individual participant.

Conflicts of Interest

None.

Author Contributions

The study was conceived and designed by Ali Jamshidi and Kazem Alizadeh-Barzian. Data collection was carried out by Abolhasan Difrakhsh, Mehdi Jamshidi, Zahra Nikkhooy, and Masoud Parash. Statistical analyses were performed by Mohamad Sabaghan, Kazem Alizadeh-Barzian, and Mehdi Jamshidi. The manuscript was written by Ali Jamshidi. Mohammad Amin Ghatee was responsible for editing the final manuscript and generating the GIS-based maps.

Data Availability Statement

All data supporting the findings of this study are included within the article.

Use of Artificial Intelligence

No artificial intelligence was used in this manuscript.

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Cite this article as:
Alizadeh-Barzian K, Ghatee MA, Jamshidi M, Sabaghan M, Difrakhsh A, Nikkhooy Z, et al. Epidemiological and geographical features of cutaneous leishmaniasis in Southwestern Khuzestan. *Med Lab J.* 2026;20(3):18-23. http://dx.doi.org/10.29252/mlj.20.3.18