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Epidemiological Assessment of Leishmaniasis in Tibesti Province, Chad (2021-2025)

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Abstract

Visceral leishmaniasis remains a major neglected tropical disease and an important public health challenge in the Tibesti province of Chad. During this five-year period, cutaneous leishmaniasis was very rare, with only a few isolated cases. This study aimed to characterize the epidemiological profile of leishmaniasis in Tibesti between 2021 and 2025. It was conducted at the Bardai hospital. Data were collected from laboratory registers. All suspected cases of leishmaniasis were confirmed through laboratory testing. Of the 1031 suspected cases, 232 were confirmed positive, yielding a positivity rate of 22.5%. Visceral leishmaniasis accounted for the overwhelming majority of cases

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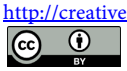


(97.4%), whereas cutaneous leishmaniasis was infrequent (2.6%). The disease disproportionately affected children under five years of age (52.2%) and males (77.4%). The Analysis revealed a high concentration of cases in the Bardai and Zouar health districts. An increasing trend was observed over the study period, with the positivity rate rising from 19.0% in 2021 to 33.6% in 2025. These findings underscore the urgent need to strengthen surveillance systems and improve access to early diagnosis and treatment, particularly among high-risk populations.

Keywords

Leishmaniasis, Epidemiology, Prevalence, Tibesti, Chad

1. Introduction

Leishmaniasis is a parasitic disease caused by protozoa of the genre Leishmania, transmitted to humans through the bite of infected phlebotomes [1] [2]. It is a protzoal infectious disease characterized by the presence and multiplication of flagellated parasites of the genre Leishmania within the cells of the mononuclear phagocytic system [3] [4]. There are three main clinical forms of leishmaniasis: visceral leishmaniasis, the most severe form, which is almost always fatal if left untreated; cutaneous leishmaniasis, the most common form, which generally causes skin ulcers; and mucocutaneous leishmaniasis, which affects the mucous membranes of the mouth, nose, and throat [5]. According to the WHO, the case definitions are as follows:

1) A suspected case of VL is defined as any person with a fever that has persisted for more than two weeks, accompanied by splenomegaly and/or hepatomegaly, weight loss, pallor, or other signs of impaired general health, who resides in an endemic area. The diagnosis is confirmed by serological tests and/or detection of the parasite;

2) Confirmed cases: A confirmed case of visceral leishmaniasis (VL) is a suspected case in which infection with Leishmania spp. has been confirmed by laboratory tests;

3) A suspected case of CL is defined as any person with one or more chronic skin lesions that have been present for more than two weeks, do not respond to standard antibacterial treatments, and who resides in or has traveled to an area where cutaneous leishmaniasis is endemic;

4) A confirmed case of CL is a suspected case in which infection with Leishmania spp. is confirmed by a laboratory test that detects the parasite or its genetic material;

5) A local or indigenous case of CL is a confirmed case in a person who contracted the infection in the geographic area where the diagnosis was made, with no recent history of travel to another endemic area during the incubation period;

6) An imported case of CL is a confirmed case in a person who contracted the

infection outside the region where the diagnosis was made, usually after a stay in another region or country where the disease is endemic [5].

Leishmaniasis represents a major public health problem in many regions of the world, particularly in arid and resource-limited settings [6] [7]. Globally, an estimated 700,000 to 1 million new cases of leishmaniasis occur annually, including 50,000 to 90,000 cases of visceral leishmaniasis. However, these figures are likely underestimated due to underreporting [8]. Leishmaniasis is endemic in more than 90 countries worldwide, particularly in Africa, Asia, and Latin America [9], Visceral leishmaniasis is especially prevalent in East Africa and certain regions of the Sahel [10]. In Chad, epidemiological data on leishmaniasis in general, and on its visceral form in particular, remain limited due to poor disease awareness, insufficient technical capacity for parasitological diagnosis, and the lack of appropriate data collection tools. In the Tibesti province specifically, epidemiological data are scarce and fragmented. In this context, there is a critical need to better understand the dynamics of leishmaniasis in this region [5]. Therefore, this study aims to assess the epidemiology of leishmaniasis in the Tibesti province of Chad over the period 2021-2025.

2. Materials and Methods

2.1. Study Type, Period

This is a descriptive and analytical epidemiological study of leishmaniasis cases reported in the Tibesti province between 2021 and 2025.

2.2. Study Sites

Data collection was conducted in the provincial hospital of Bardai. Located in the northwestern part of the country, this province is characterized by a Saharan climate, with virtually no annual rainfall and temperatures ranging from below 0˚C to 45˚C. The provincial capital is Bardai, located approximately 1764 km north of N'Djamena along the Faya road, and the province is divided into two departments: East Tibesti and West Tibesti. Samples were collected in Bardai from patients coming from 25 localities. These included: Baradi, Zouar, Miski, Zoui, Zoumri, Zoughoura, Min D'or, Moddra, Yebibou, Ousouni, Torko, Min Azo, Charda, Goubone, Tarso, Wour, Aouzou, Guereda, Youbousama, Zouarke, Lybie (Banghazi), Youdei, Emi Koussi and Tchoboura.

2.3. Sample Collection

Blood samples were collected during Outpatient consultations in both health districts. Any patient residing in Tibesti Province or who had stayed there and who exhibited clinical signs suggestive of leishmaniasis was referred to the laboratory for diagnostic confirmation. Data were collected from hospital registries and disease surveillance reporting forms throughout the province. Patients with positive test results were treated in the provincial hospital in Bardai.

2.4. Laboratory

The rK39 rapid diagnostic test (RDT) was used to confirm the clinical suspicion of leischmaniasis, in accordance with the manufacturer's instructions. This test is based on the detection of anti-Leishmania antibodies directed against the rK39 antigen. The rK39 test is recommended by the WHO as the first-line test for diagnosing visceral leishmaniasis in endemic areas. It is currently the only test available for screening for visceral leishmaniasis. The performance of the rK39 test varies depending on the geographic region, the Leishmania species involved, and the patient's immune status. The limitations of the rK39 test are as follows:

- Detects antibodies, not the parasite;
- False negatives;
- False positives;
- Limited use; not recommended for the diagnosis of cutaneous leishmaniasis; not recommended for monitoring treatment.

For cutaneous leishmaniasis, a direct slide examination was performed by scraping from the lesion using a vaccinostyle or by needle aspiration. This allowed for the identification of Leishmania amastigotes inside and outside histiocytes following May-Grünwald-Giemsa (MGG) staining. In Chad, microscopy remains the most accessible method for confirming a diagnosis, but samples can be sent to reference laboratories for molecular identification via PCR or sequencing.

2.5. Treatment

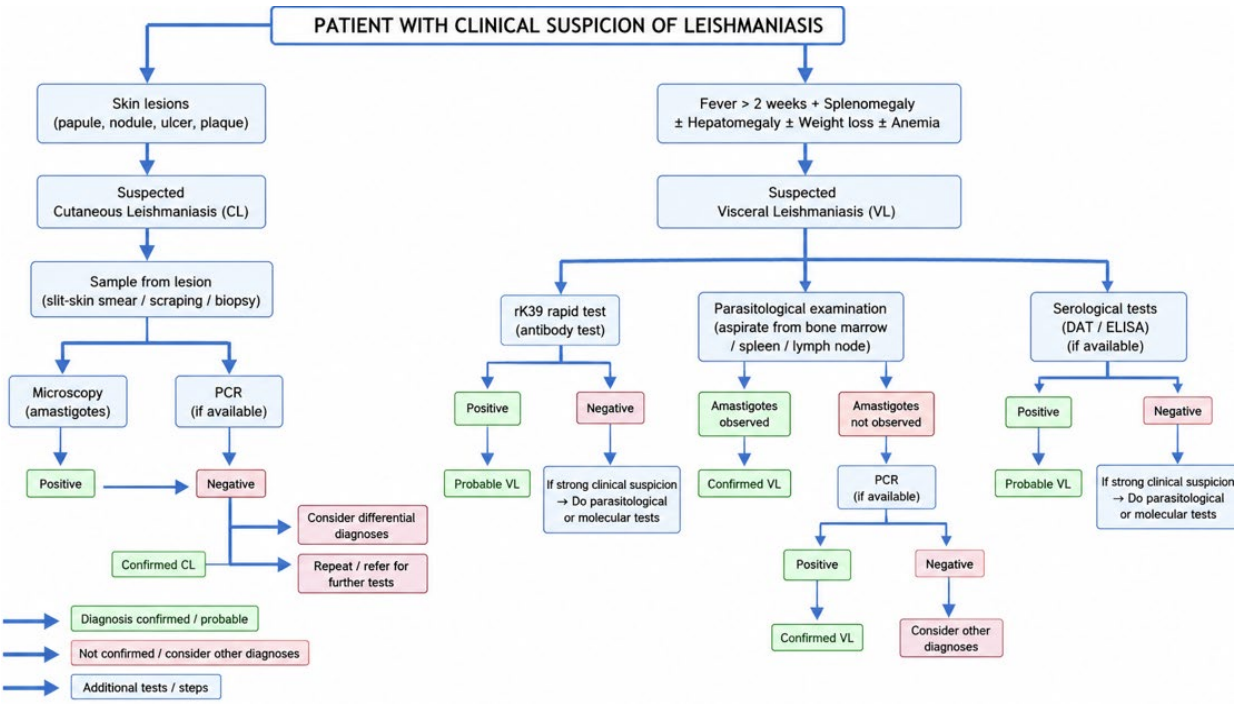


Figure 1. Diagnostic algorithm.

For the treatment of leishmaniasis, clinicians prescribed the following medica-

tions. In cases of VL, patients received or Sodium stibogluconate and paramomycin administered according to their body weight for 17 days. In cases of CL, patients were treated either by intralesional infiltration of sodium stibogluconate around the lesion or by intramuscular injections of sodium stibogluconate adjusted for body weight for 30 days. The patients were followed up for one month after treatment. Below is diagnostic algorithm (Figure 1).

2.6. Ethical Considerations

The data presented in this article were authorized by the Tibesti Provincial Health Delegate and approved by the laboratory staff at the Bardai Provincial Hospital.

2.7. Statistical Analysis

All data were entered into Word and then analyzed using Excel and GraphPad version 10.

3. Results

Between January 2021 and December 2025, the Bardai Hospital laboratory tested 1031 patients suspected of having leishmaniasis. Of which, 226 cases of VL and 6 cases of CL for a total of 232 positive cases of leishmaniasis were treated, corresponding to the test positivity rate of 22.50% (232/1031). With regard to the overall the prevalence, it is the number of cases per head of population at any one time. This the proportion of VL compared to the total cases of leishmaniasis in Tibesti Province, VL is a significant public health problem with a rate of 97.41% (226/232), while CL is underrepresented at 2.59% (6/232) (see below) (Figure 2).

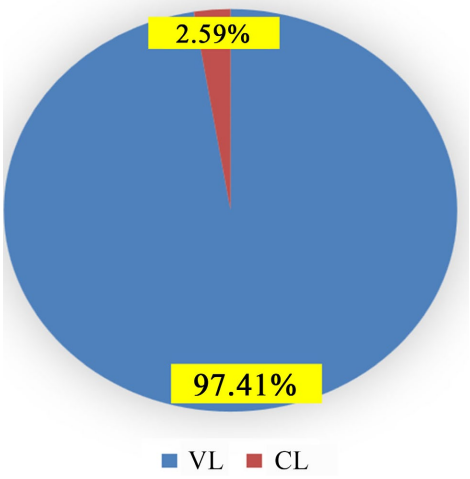


Figure 2. Prevalence of different leishmaniasis types in Tibesti province.

This graph shows the distribution of leishmaniasis cases by year (2021-2025) and by disease type (VL, CL). Furthermore, the graph shows that VL cases increase significantly in 2025, increasing from 18.53% (43/232) to 32.76% (76/232). During this five-year period, CL is very rare, with cases emerging in 2024 at 2.59%

(6/232) (Figure 2). Between 2021 and 2025, 226 patients were enrolled, of whom 77.43% (157/226) were male and 51/226 (22.57%) were Female (Table 1).

Table 1. Distribution of VL cases by sex and year (2021-2025).

Years	Confirmed cases (%)	Sex	
		Male (%)	Female (%)
2021	43 (19.03)	27 (15)	16 (34.78)
2022	24 (10.62)	20 (11.11)	4 (8.69)
2023	39 (17.26)	22 (12.22)	17 (36.96)
2024	44 (19.47)	41 (7.78)	3 (6.52)
2025	76 (33.63)	70 (38.88)	6 (13.04)
Total	226 (100)	180 (79.65)	46 (20.35)

Figure 3 should have a percentage. The age groups are of different sizes not representing the true scale of the problem for children, 0 to 5 were the most represented, with 52.21% (118/226), followed by those aged 6 - 20, 21 - 41, 41 - 60, and 61 - 64, with 21.68% (49/226), 19.03% (43/226), 6.64% (15/226), and 0.44% (1/226) (Figure 3).

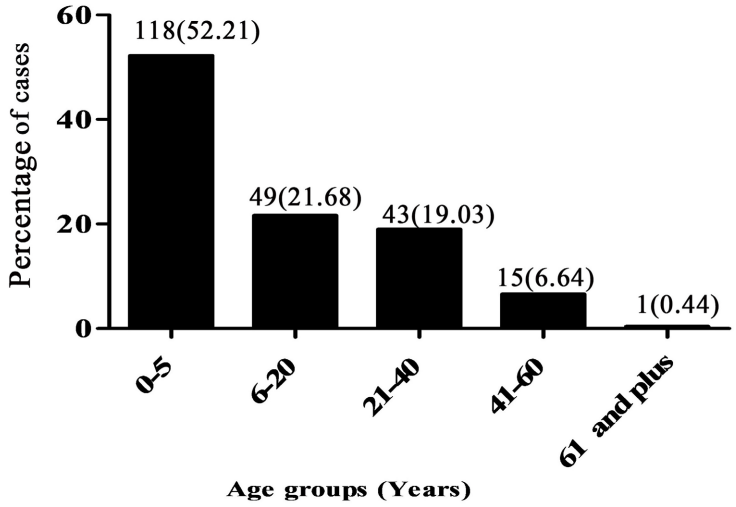


Figure 3. Distribution of VL cases by age group (2021-2025).

After five (5) years, leishmaniasis infection rates varied from one locality to another, with the towns of Bardai and Zouar leading the way with the test positivity rates of 20.8% (47/226) and 15. 93% (36/226) respectively, followed by the towns of Guéreda and Benghazi (Libya), Youdei, and Emi Kossi, with a similar the test positivity rate of 0.44% (1/226). Similarly, for Tarsou and Zouarké, the test positivity rate is low, with 0.88% (2/226). We observed throughout the study period that the test positivity rate increased from 19.03% (43/226) in 2021 to 33.63% (76/226) in 2025 (Table 2).

Table 2. Distribution of VL cases by provenance and year (2021-2025).

Residence	2021	2022	2023	2024	2025	Total	Frequence (%)
Bradai	13	9	5	8	12	47	20.80
Zouar	7	2	11	7	9	36	15.93
Miski	5	2	7	2	1	17	7.52
Zoughoura	6	0	4	2	4	16	7.08
Zoui	2	4	0	0	9	15	6.64
Min D'or	0	0	0	0	14	14	6.19
Zoumri	2	0	0	4	6	12	5.31
Moddra	4	6	0	0	0	10	4.42
Yebibou	3	2	0	4	0	9	3.98
Ousouni	0	0	0	0	7	7	3.10
Wour	1	0	3	0	0	4	1.77
Aouzou	0	0	0	0	5	5	2.21
Charda	0	0	0	6	0	6	2.65
Min Azo	0	0	0	0	5	5	2.21
Orpailleur	0	0	0	3	1	4	1.77
Torko	0	0	0	0	3	3	1.33
Youbousama	0	0	0	0	3	3	1.33
Goubone	0	0	1	3	0	4	1.77
Guereda	0	0	0	0	1	1	0.44
Lybie (Banghazi)	0	0	0	1	0	1	0.44
Youdei	0	0	0	1	0	1	0.44
Emi Koussi	0	0	0	1	0	1	0.44
Tchoboura	0	0	0	1	0	1	0.44
Tarso	0	0	2	0	0	2	0.88
Zouarke	0	0	0	0	2	2	0.88
Total (%)	**43 (19.03)**	**24 (10.62)**	**39 (17.26)**	**44 (19.47)**	**76 (33.63)**	**226**	**100.00**

The transmission of VL is mostly local. During the 2021-2025 period, 98.23% (222/226) of reported cases were locally acquired, compared with 1.77% (4/226) of cases imported (Table 3).

Table 3. Transmission of cases in Tibesti province.

Transmission	Number	Frequencies (%)
Local	222	98.23
Imported	4	1.77
Total	**226**	**100.00**

From 2021 to 2025, the health district most affected was Bardai, with 75% of cases (174/232), followed by Zouar and other districts, with 23% (54/232) and 2% (4/232), respectively (Figure 4).

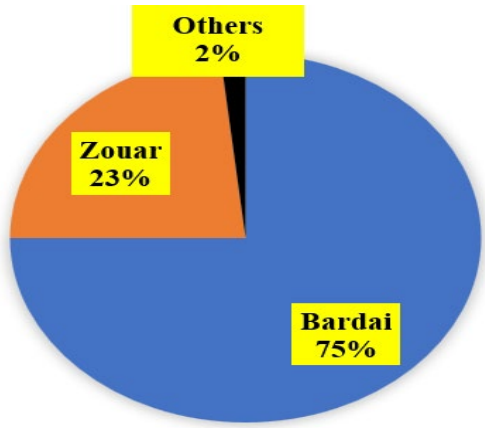
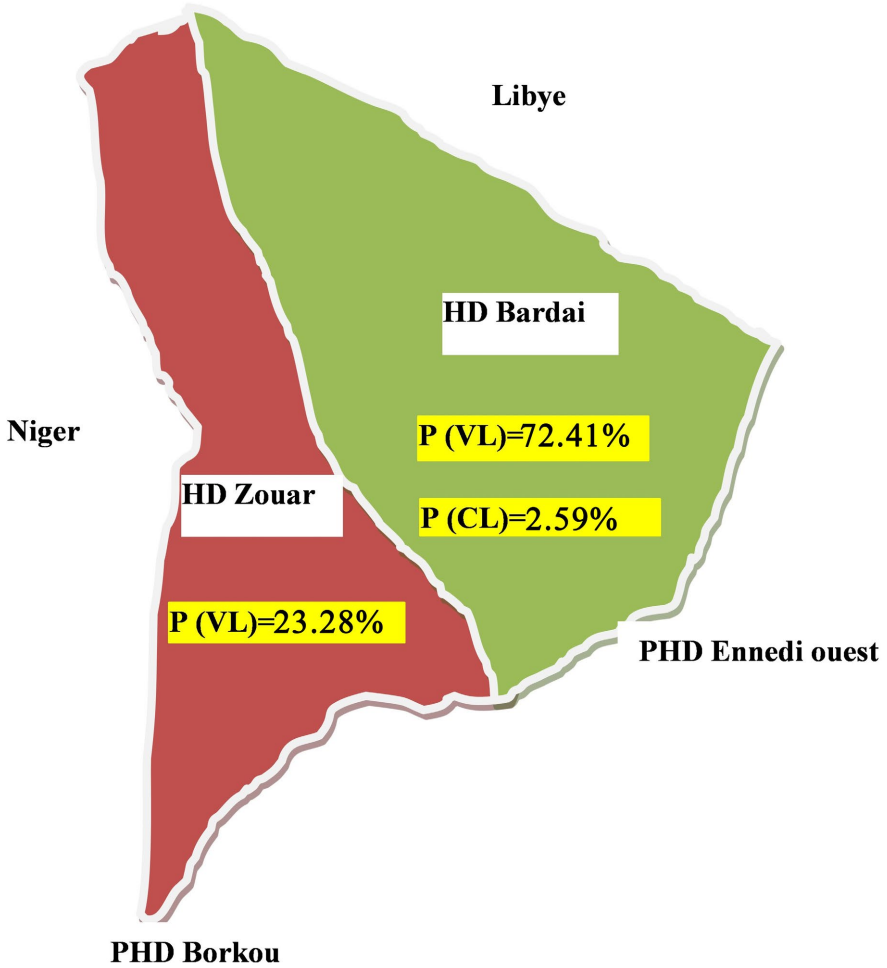


Figure 4. Case distribution by health district.



Note: Source: Bardai Hospital.

Figure 5. Prevalence of leishmaniasis in the Tibesti provincial health delegation.

This study mapped the distribution of leishmaniasis in the Tibesti Provincial Health Delegation. In the Bardai health district, two (2) types of parasites VL and CL were identified, with a high prevalence of VL (72.41%, or 168/232) compared to a low the test positivity of CL (2.59%, or 6/232). In the Zouar health district, we found only cases of VL, with a prevalence of 23% (54/232); no cases of CL were observed (**Figure 5**).

4. Discussion

The results of this study show that, of the 1031 patients with suspected cases examined between 2021 and 2025 in Bardai Hospital, 232 cases of leishmaniasis were confirmed, a positivity rate of 22.50%. This relatively high proportion suggests that the parasite is widespread in Tibesti Province, particularly in high-risk areas. In Chad, artisanal gold mining and urbanization are now two major factors influencing the epidemiology of leishmaniasis. It is essential to take these factors into account to strengthen surveillance, improve prevention strategies, and guide control programs, particularly in regions with high population mobility, such as northern Chad. At the same time, urban transmission of leishmaniasis is an emerging phenomenon in several regions of the world. The expansion of cities into peri-urban areas also facilitates contact between human populations and vectors.

This finding is supported by WHO data, which indicate that leishmaniasis remains highly endemic in the Sahelian regions and in resource-limited areas, where access to diagnosis is often limited [8]. Furthermore, results from other studies have also shown that positivity rates can be high in areas where clinical suspicion is high [9]. The high percentage of visceral leishmaniasis (97.41%) compared to the cutaneous form (2.59%) observed in this study confirms that the Tibesti region is primarily a reservoir for visceral leishmaniasis (**Figure 1**). This finding is supported by other studies, which show that visceral leishmaniasis is the predominant form in East Africa and the Sahelian area [11] [12]. The predominance also not no dogs and few rodents for CL reservoir whereas humans are the VL reservoir of the visceral form observed in this study could be explained by the ecological conditions of the Tibesti region, such as the arid climate, precarious living conditions, and the presence of vectors (phlebetomes). In addition, gold panning activities increase population mobility and lead to increased exposure to vectors. Furthermore, the low proportion of CL cases observed could be explained by underdetection or underreporting of this form of the disease, which is often less severe and therefore less likely to lead to a hospital visit. This phenomenon is widely described in the literature [1] [9] [13]. **Figure 2** illustrates the annual evolution of the incidence of VL and CL in Tibesti Province between 2021 and 2025. The trend shows fluctuations followed by a marked increase, from 43 cases (18.53%) in 2021 to 76 cases (32.76%) in 2025. This trend follows an overall upward trajectory, with a peak in 2025. However, no cases of CL were detected between 2021 and 2023. Cases reappeared in 2024 at a rate of 2.59%, then again disappeared in 2025. The

low incidence of CL corresponds to certain regions of Africa where VL is predominant [5] [8] [14]. The results revealed a strong male predominance in the incidence of VL in Tibesti Province, with 77.43% of cases affecting males compared to 22.57% of females (**Table 1**). This male predominance is well documented in the literature, particularly in endemic areas [1] [9] [15]. However, professional factors play a decisive role. In Tibesti Province, gold panning activities, which are largely dominated by men, expose workers to environmental conditions conducive to the transmission of leishmaniasis. Furthermore, the use of personal protective measures such as mosquito nets and repellents often remains insufficient among these vulnerable populations. The adults with the disease are not native to the Tibesti and were not exposed as children. An analysis of the distribution of leishmaniasis cases by age group reveals a marked prevalence among children aged 0 to 5 years, who account for 52.21% of cases (118/226). This proportion is significantly higher than that of other age groups, followed by the 6 - 20 age group (21.68%) and the 21 - 40 age group (19.03%). Older adults (ages 41 - 60) and people aged 61 and older are significantly underrepresented (**Figure 2**). This distribution suggests that young children are the group most vulnerable to VL in Tibesti Province. This finding is consistent with several studies on this topic, in which VL primarily affects children in areas of stable transmission [9] [12] [14]. The patient's immune status, malnutrition, and environmental conditions could explain the high prevalence observed among children under 5 years of age in this study [4]. In addition, we observed significant variations in leishmaniasis infection rates across different localities, with a notable number of cases detected in certain specific areas of Tibesti Province. The towns of Bardai (20.8%) and Zouar (15.93%) appear to be the main foci of the disease, while other localities such as Guéréda, Benghazi, Youdei, and Emi Kossi have very low (0.44%) or even negligible rates (**Table 1**). The high number of cases observed in Bardai and Zouar could be explained by several factors. On this point, these localities are areas with high population density, particularly due to artisanal gold mining activities, which promote close contact and exposure to sandflies. Furthermore, local ecological conditions provide habitats conducive to the development of phlébotomes. Similar observations have been reported in certain studies [9] [15]. Spatial and temporal analysis of VL cases in Tibesti Province reveals a heterogeneous geographic distribution, with significant pockets in Bardai and Zouar and a progressive increase in the number of cases between 2021 and 2025. **Table 3** shows an absolute predominance of local transmission of VL (98.23%) in Tibesti Province, while imported cases remain low (1.77%). This distribution is concordant with data from the literature reported by other researchers [1] [16]. The high proportion of indigenous cases observed in this study confirms that VL is highly endemic in Tibesti Province. Other authors have made similar observations, stating that VL transmission is often sustained by regular community contact among people living in endemic areas [9]. Although they represent a minority (1.77%), the imported cases observed in this study are concordant with data from other studies, which indicate that human

mobility plays a secondary but significant role in the transmission of leishmaniasis among neglected tropical diseases; cross-border movements can introduce new cases into non-endemic areas, alter local transmission dynamics, and promote the emergence of new foci [15] [17]. In the context of the Tibesti region, exchanges with areas such as Libya could explain the presence of these imported cases. Similarly, the results show a high proportion of visceral leishmaniasis cases in Bardai (75%), followed by Zouar (23%), while the other localities account for only 2% of cases. This distribution highlights a significant spatial disparity, characteristic of endemic foci of leishmaniasis (**Figure 4**). The predominance of Bardai as the primary focus corresponds to recent observations from certain studies [18]. In this context, Bardai could constitute an epicenter of transmission, where environmental and human conditions favor intense circulation of the parasite. The high number of cases in Bardai and Zouar suggests that urban or semi-urban areas play a key role in transmission dynamics. Similarly, the results show a high proportion of visceral leishmaniasis cases in Bardai (75%), followed by Zouar (23%), while the other localities account for only 2% of cases. This distribution highlights a significant spatial disparity, characteristic of endemic foci of leishmaniasis (**Figure 4**). The predominance of Bardai as the primary focus corresponds to recent observations from certain studies [18]. In this context, Bardai could constitute an epicenter of transmission, where environmental and human conditions favor intense circulation of the parasite. The high number of cases in Bardai and Zouar suggests that urban or semi-urban areas play a key role in transmission dynamics. Studies conducted elsewhere confirm that high-incidence clusters are often located in areas characterized by high economic activity and high population mobility [9] [19]. The low proportion of cases in other localities (2%) is also consistent with recent data, which indicate the existence of areas with low transmission and areas where transmission is silencious or underreported [20], this situation could be linked to less favorable ecological conditions, low vector density, or limited access to health services. The study highlights a heterogeneous distribution of leishmaniasis within the Tibesti Provincial Health Delegation, with a concentration of cases in the health districts of Bardai and Zouar. Two forms of the disease (VL and CL) were identified only in the Bardai district, while the Zouar district has only cases of visceral leishmaniasis (**Figure 5**). The number of cases of VL in Bardai (72.41%) and Zouar (23%) confirms that VL is the dominant form in the Tibesti province. CL, which has a very low prevalence (2.59%), appears to be marginal and limited to Bardai. These results are concordant with the observations of certain authors, who indicate that the VL form is predominant in sub-Saharan Africa, particularly in Sahelian regions, where it is associated with Leishmania donovani [20] [21]. In Central and East Africa, diagnosing leishmaniasis remains a major challenge due to its sometimes non specific clinical manifestations and the limited availability of parasitological and molecular testing methods. It is essential to strengthen diagnostic and surveillance capabilities in order to improve early detection and case management [2] [5] [22]. The presence of the two

forms (VL and CL) exclusively in the Bardai district suggests that this region has more varied ecological and epidemiological conditions, which favor the circulation of multiple Leishmania species. In contrast, the absence of CL cases in Zouar could be explained by environmental conditions less favorable to CL transmission, a low density of specific vectors, or underdetection of cutaneous forms, which are often less severe and less frequently diagnosed [23] [24].

Studies have shown that the distribution of the various forms of leishmaniasis depends heavily on the type of vector present, animal reservoirs, and climatic and ecological conditions. In some regions, the visceral and cutaneous forms coexist, while in others, a single form predominates [20] [25]-[27]. Leishmaniasis in Tibesti Province is characterized by a predominance of the visceral form, a focal and heterogeneous distribution, and variability among health districts. Bardai appears to be a more complex focus, while Zouar appears to be an exclusively visceral focus. This study highlights that leishmaniasis represents a major public health problem in Tibesti Province, characterized by high endemicity, primarily local transmission, and a gradual increase in the number of cases between 2021 and 2025. The disease primarily affects young children and adult men, reflecting both household and professional modes of transmission. The highly localized geographic distribution, dominated by the Bardai and Zouar, highlights the decisive influence of environmental and socioeconomic factors. These findings highlight the need to strengthen epidemiological surveillance, improve access to early diagnosis, and implement prevention strategies tailored to the local context.

5. Limitations of the Study

- The diagnosis was based primarily on clinical data, rapid tests, and/or parasitological examinations;
- The study was conducted in a specific geographic area of the Tibesti region. The results, therefore, cannot be extrapolated to Chad as a whole;
- No entomological study was conducted to confirm the density or distribution of vector sandfly species at the study sites;
- There was no assessment of the ecological factors influencing the spatial distribution of the disease.

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Author Contributions

IMS, DAS, MMHT, KHC: drafting of the article; AD, MAAS, MAO, AIM, MAH, AJH: data collection; protocol design and drafting: MA, IAH, HM, NO, AB, MID, MA, MZZ, DJE, HMA, MJH; data analysis: MSID, IK, OMD, AMO, BBO, MAB; protocol review and validation.

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Conflicts of Interest

The authors declare that they have no conflicts of interest. The Tibesti Provincial Health Delegation and the Bardai Hospital Laboratory are solely responsible for the results presented in this publication.

References

[1] Desjeux, P. (2001) The Increase in Risk Factors for Leishmaniasis Worldwide. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, **95**, 239-243. https://doi.org/10.1016/s0035-9203(01)90223-8

[2] WHO (2024) Global Leishmaniasis Surveillance Updates 2024: Consolidating Gains and New Initiatives. https://www.who.int/publications/i/item/who-wer10045-535-552

[3] Messaoudene, F., Boukraa, S., Boubidi, S.C., Guerzou, A. and Ouahabi, A. (2023) Human Cutaneous Leishmaniasis in North Africa and Its Threats to Public Health: A Statistical Study Focused on Djelfa (Algeria). *Microorganisms*, **11**, Article 2608. https://doi.org/10.3390/microorganisms11102608

[4] Ramsay, A. and Kamau, E.M. (2025) Neglected Tropical Diseases Remain a Considerable Public Health Challenge in West Africa. *Tropical Medicine and Infectious Disease*, **10**, Article 77. https://doi.org/10.3390/tropicalmed10030077

[5] WHO (2022) WHO Guideline for the treatment of visceral leishmaniasis in HIV co-infected patients in East Africa and South-East Asia. World Health Organization. https://www.who.int/publications/b/57413

[6] Osuolale, O. (2023) Visceral and Tegumentary Leishmaniasis. In: *Vaccines for Neglected Pathogens: Strategies, Achievements and Challenges*, Springer International Publishing, 235-261. https://doi.org/10.1007/978-3-031-24355-4_11

[7] WHO (2021) Appuie le Tchad dans ses efforts à lutter contre une maladie tropicale négligée mortelle: La Leishmaniose viscérale. https://www.afro.who.int/fr/news/loms-appuie-le-tchad-dans-ses-efforts-lutter-contre-une-maladie-tropicale-negligee-mortelle-la

[8] WHO (2010) Control of the Leishmaniases. WHO Technical Report Series 949. OMS.

[9] Chappuis, F., Sundar, S., Hailu, A., Ghalib, H., Rijal, S., Peeling, R.W., *et al.* (2007) Visceral Leishmaniasis: What Are the Needs for Diagnosis, Treatment and Control? *Nature Reviews Microbiology*, **5**, 873-882. https://doi.org/10.1038/nrmicro1748.

[10] Geto, A.K., Berihun, G., Berhanu, L., Desye, B. and Daba, C. (2024) Prevalence of Human Visceral Leishmaniasis and Its Risk Factors in Eastern Africa: A Systematic Review and Meta-Analysis. *Frontiers in Public Health*, **12**, Article 1488741. https://doi.org/10.3389/fpubh.2024.1488741

[11] Cook, G.C. and Zumla, A. (2009) Malaria. Manson's Text Book of Tropical Diseases. 22nd Edition, Saunders Press.

[12] Leta, S., Dao, T.H.T., Mesele, F. and Alemayehu, G. (2014) Visceral Leishmaniasis in

Ethiopia: An Evolving Disease. *PLOS Neglected Tropical Diseases*, **8**, e3131. https://doi.org/10.1371/journal.pntd.0003131

[13] Desjeux, P. (2004) Leishmaniasis: Current Situation and New Perspectives. *Comparative Immunology, Microbiology and Infectious Diseases*, **27**, 305-318. https://doi.org/10.1016/j.cimid.2004.03.004

[14] Hotez, P.J. and Kamath, A. (2009) Neglected Tropical Diseases in Sub-Saharan Africa: Review of Their Prevalence, Distribution, and Disease Burden. *PLOS Neglected Tropical Diseases*, **3**, e412. https://doi.org/10.1371/journal.pntd.0000412

[15] Selvapandiyan, A., Shital, S., Sangma, D.A., Jain, M., Karunaweera, N. and Ganguly, N.K. (2025) An Update on Clinical and Pathogenic Spectra of Leishmaniasis. *Expert Reviews in Molecular Medicine*, **27**, e27. https://doi.org/10.1017/erm.2025.4

[16] Diro, E., Lynen, L., Ritmeijer, K., Boelaert, M., Hailu, A. and van Griensven, J. (2014) Visceral Leishmaniasis and HIV Coinfection in East Africa. *PLOS Neglected Tropical Diseases*, **8**, e2869. https://doi.org/10.1371/journal.pntd.0002869

[17] WHO (2024) Global Report on Neglected Tropical Diseases. https://www.who.int/teams/control-of-neglected-tropical-diseases/global-report-on-neglected-tropical-diseases-2024

[18] Alvar, J., Beca-Martínez, M.T., Argaw, D., Jain, S. and Aagaard-Hansen, J. (2023) Social Determinants of Visceral Leishmaniasis Elimination in Eastern Africa. *BMJ Global Health*, **8**, e012638. https://doi.org/10.1136/bmjgh-2023-012638

[19] Torres-Guerrero, E., Quintanilla-Cedillo, M.R., Ruiz-Esmenjaud, J. and Arenas, R. (2017) Leishmaniasis: A Review. *F*1000 *Research*, **6**, 750. https://doi.org/10.12688/f1000research.11120.1

[20] Talbi, F.Z., El Khayyat, F., El Omari, H., Maniar, S., Fadil, M., Taroq, A., *et al.* (2020) Cartography and Epidemiological Study of Leishmaniasis Disease in Sefrou Province (2007–2010), Central North of Morocco. *Interdisciplinary Perspectives on Infectious Diseases*, **2020**, 1-8. https://doi.org/10.1155/2020/1867651

[21] Kumar, S., Alghamdi, A., Singh, P.K., Pal, N., Pattnaik, R., Alissa, M., *et al.* (2026) Neglected Tropical Diseases: Recent Trends and Challenges Associated with Its Rapid Diagnosis and Effective Therapeutic Strategies. *Frontiers in Pharmacology*, **17**, Article 1742086. https://doi.org/10.3389/fphar.2026.1742086

[22] WHO (2026) Global Leishmaniasis Surveillance Updates 2023: 3 Years of the NTD Road Map. https://iris.who.int/bitstream/handle/10665/379491/WER9945-653-669.pdf?sequence=1

[23] Sundar, S. and Chakravarty, J. (2015) An Update on Pharmacotherapy for Leishmaniasis. *Expert Opinion on Pharmacotherapy*, **16**, 237-252. https://doi.org/10.1517/14656566.2015.973850

[24] Zijlstra, E.E. and El-Hassan, A.M. (2001) Post kala-azar dermal leishmaniasis. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, **95**, S59-S76. https://doi.org/10.1016/s0035-9203(01)90219-6

[25] Reithinger, R., Dujardin, J.C., Louzir, H., Pirmez, C., Alexander, B. and Brooker, S. (2007) Cutaneous Leishmaniasis. *The Lancet Infectious Diseases*, **7**, 581-596. https://doi.org/10.1016/s1473-3099(07)70209-8

[26] Alvar, J., Vélez, I.D., Bern, C., Herrero, M., Desjeux, P., Cano, J., *et al.* (2012) Leishmaniasis Worldwide and Global Estimates of Its Incidence. *PLOS ONE*, **7**, e35671. https://doi.org/10.1371/journal.pone.0035671

[27] Burza, S., Croft, S.L. and Boelaert, M. (2018) Leishmaniasis. *The Lancet*, **392**, 951-970. https://doi.org/10.1016/s0140-6736(18)31204-2

Abbreviations

RDT	Rapid diagnostic test
MGG	May-Grünwald Giemsa
VL	Visceral Leishmaniasis
CL	Cutaneous Leishmaniasis
WHO	World Health Organization
PHD	Provincial Health Delegation
HD	Health District