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A RESEARCH ARTICLE

Spatial concentration and seasonal clustering of cutaneous leishmaniasis in Mosul, Iraq: a retrospective patient data-based analysis

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Abstract

Cutaneous leishmaniasis remains a major public health issue in Iraq, with potential influences including local environment, vector ecology, environmental change, human migration, and travel. We reviewed 191 hospital records deemed suitable for analysis in Mosul, obtained from Mosul General Hospital for the period 2025-2026. Available variables were sex, age, diagnostic result, date, and address. Diagnosis in routine practice was based on lesion smear together with clinical and laboratory assessment. Categorical variables were summarized as frequencies and percentages. Age was described by mean, standard deviation, median, interquartile range, and range. Group comparisons were performed using Pearson's chi-square test or Fisher's exact test for categorical variables and the Mann-Whitney U test for age. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated for selected 2x2 comparisons. 191 records, 175 were positive and 16 were negative, yielding a positivity of 91.6% (95% CI, 86.8%-94.8%). Positive records were predominantly male in absolute number (63.4%), but positivity did not differ significantly by sex within the tested hospital population (Fisher's exact p = 0.424). The age of positive records ranged from 0.5 to 75 years, with a mean of 23.3 ± 20.2 years and a median of 20 years (IQR, 5-36). The largest age stratum was 25-44 years (24.6%), followed by 5-14 years (22.3%) and 1-4 years (18.9%). Female positive records were younger than male positive records (median, 12 vs 25 years; Mann-Whitney U p = 0.033). Positive records were concentrated in November-February (66.9%), with peaks in November and December. When months were collapsed into November-February versus March-October, a higher proportion of positivity was observed in the cooler-month cluster (OR, 2.59; 95% CI, 0.92-7.31), although this did not reach formal statistical significance (Fisher's exact p =< 0.005). At the locality level, Muhalbia, Alshoora, Hamamali, Qaeera, and Talabta accounted for 53.1% of all positive records. showed a strongly focal distribution of cutaneous leishmaniasis records in both time and place. These findings support geographically targeted surveillance and control within the hospital catchment while underscoring the limits of hospital-record data for estimating population-level incidence

1. INTRODUCTION

Leishmaniasis is a vector-borne protozoan disease caused by Leishmania spp. and transmitted by infected female phlebotomine sand flies. Cutaneous leishmaniasis is the most common clinical form and remains a major neglected tropical disease in the Middle East [1]. Poverty, weak housing conditions, environmental disruption, displacement, and gaps in diagnosis and control amplify its burden. Iraq remains one of the affected countries in the WHO Eastern Mediterranean Region, where both zoonotic and anthroponotic transmission patterns are relevant to cutaneous leishmaniasis epidemiology [1,2]

The epidemiology of cutaneous leishmaniasis is inherently focal. Transmission depends on the local interactions among the parasite, vector, reservoir, and human host. Seasonal abundance of sand flies, reservoir proximity, peri-domestic ecology, rural exposure, housing quality, and human movement all contribute to marked spatial heterogeneity[3-6]. Some studies have shown heterogeneity at the district level in Iraq and across provincial studies, including Diyala, Erbil, Al-Muthanna, Kurdistan, and central provinces. Clustering of regions, peak periods (winter) [2-4,7].

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The outbreak behaviors of leishmaniasis, and the Leishmania ecology have all been documented at various levels in these locations From both clinical practice and laboratory tests, the definitive diagnosis of cutaneous leishmaniasis in endemic regions is frequently based on the identification of compatible lesions and the results of a direct smear or clinical assessment, but PCR provides greater sensitivity to identify the Leishmania species. That distinction is epidemiologically important.[2,6]. Smear-supported hospital datasets are useful for describing record burden and care presentation, but they cannot resolve species, transmission pathways, or community incidence without molecular and denominator-based follow-up [8-10]

The present manuscript was developed from a hospital spreadsheet from Mosul containing sex, age, result, date, and address. Its scientific value lies in defining how the recorded cutaneous leishmaniasis burden was distributed across months and localities within the hospital catchment. The central question was whether the record burden was diffuse or concentrated in identifiable temporal and locality-level clusters.

2. Materials and Methods

2.1. Study design and data source

A retrospective hospital-based record analysis was performed using an Excel spreadsheet of recorded cutaneous leishmaniasis cases obtained from Mosul General Hospital for the period 2025-2026. The spreadsheet contained 191 records with five variables: sex, age, diagnostic result, date, and address. All data categories were provided for statistical analysis.

2.2. Case framework

The data set records corresponded to cutaneous leishmaniasis; the diagnosis in routine hospital practice was based on lesion smear together with clinical and laboratory assessment.

2.3. Variables

The primary outcome variable was the recorded diagnostic result. Secondary variables were sex, age, month of record, and locality. Age among positive records was grouped as follows: <1 year, 1-4 years, 5-14 years, 15-24 years, 25-44 years, 45-64 years, and >=65 years. For seasonal comparison, months were collapsed into November-February versus March-October on the basis of exploratory clustering.

2.4. Statistical analysis

Categorical variables were summarized as frequencies and percentages. Age was summarized by mean, standard deviation, median, interquartile range, and range. The positivity proportion was reported with a 95% confidence interval. Associations between categorical variables were tested using Pearson's chi-square test or Fisher's exact test where appropriate. Because the negative group was small and the age distribution was non-Gaussian, age comparisons between the two groups were analyzed using the Mann-Whitney U test. Odds ratios with 95% confidence intervals were calculated for selected 2x2 comparisons. A two-sided p-value <0.05 was considered statistically significant.

3. Results and Discussion

The dataset investigated is 191 hospital files evaluated for cutaneous leishmaniasis and contained positive cases, resulting in a very high overall positivity ratio. The high proportion of positive records is consistent with the hospital-based dataset, indicating the population is selected for clinical diagnosis rather than an unselected community population. The distribution of the records by sex was overwhelmingly male in all positive records. These baseline characteristics of the underlying dataset define the structure of the analytical cohort and enable subsequent comparisons by age, seasonality, and geographic locality. (Table 1).

Due to the high percentage of patients testing positive in Mosul, caution must be exercised in making any conclusions about the prevalence of disease in Mosul. It seems that this sample of patients reflects only those individuals with clinically selected lesions from a hospital-based sample and not the prevalence of disease in the general population. A diagnostic pathway has been described where leishmaniasis was diagnosed using smears combined with clinical or laboratory assessments.

Table 1. General characteristics of the hospital-based cutaneous leishmaniasis record set

Variable	Value
Total records analyzed	191
Positive records	175
Negative records	16
Overall positivity	91.6%
95% CI for positivity	86.8%-94.8%
Male records	123 (64.4%)
Female records	68 (35.6%)
Male positive records	111/175 (63.4%)
Female positive records	64/175 (36.6%)

This method, while typical of endemic health care, will produce a higher number of false positives than will PCR and will not permit the determination of species through direct microscopic examination. Molecular studies from Iraq and the region have shown L. major and L. tropica co-occurring; PCR will improve the accuracy of the epidemiologic picture. [11- 24, 25-27].

Records of positive cases spanned all ages from birth through old age; the burden was shared across multiple age groups. The 25–44-year-old group had the most records, but very similar numbers of records were in both children and young people aged 0-24; this appears to indicate that hospital-recorded positive cases in Mosul were distributed across age groups, with adults forming an important part of the burden. The age-group frequencies are summarized in (Table 2).

Table 2. Age distribution of positive cutaneous leishmaniasis records

Age group (years)	Positive records, n (%)
<1	5 (2.9%)
1-4	33 (18.9%)
5-14	39 (22.3%)
15-24	24 (13.7%)
25-44	43 (24.6%)
45-64	22 (12.6%)
>=65	9 (5.1%)

Age summary for positive records: mean = 23.3 ± 20.2 years; median = 20 years; IQR = 5-36 years; range = 0.5-75 years.

The mean age of positive records was 23.3 years (SD, 20.2), with a median of 20 years, an IQR of 5-36 years, and a range of 0.5-75 years.

The age pattern indicates a relatively large share of adult cases, with the 25-44-year age group contributing the highest number of positives. Although pediatric cases were also common, the distribution differs from reports that emphasize a higher burden among children aged 5-14 years. In this record set, adult cases were more prominent than child cases [9,18-22].

While males were the predominant number of positive records, results indicated no statistically significant relationship between sex and positive test results in the hospital testing population. Thus, the perception of a larger ratio of males than females among those receiving a positive record in this

study more accurately reflects differences in the demographics of the overall study sample rather than a true statistically significant sex differential in diagnosis. The contingency structure, effect estimate, and exact p-values are shown in Table 3.

Table 3. Association between sex and diagnostic result

Sex	Positive n (%)	Negative n (%)	Statistical test	Effect size	P value	Significance
Female (n = 68)	64 (94.1%)	4 (5.9%)	Fisher's exact / Pearson's chi-square	OR for positivity in females vs males = 1.73 (95% CI 0.54-5.59)	0.424 / 0.514	NS
Male (n = 123)	111 (90.2%)	12 (9.8%)				

The age difference between records was not a significant measure of diagnosis for the study. In contrast, females had lower average ages than males; therefore, the average ages of patients in the entire positive group differed by sex. This finding adds a new element to our understanding of epidemiological differences based on sex; furthermore, it appears that the average age of patients is different between sexes. The comparative age statistics are presented in Table 4.

Table 4. Age comparison by diagnostic result and by sex among positive records

Comparison	Group 1	Group 2	Statistical test	Test statistic	P value	Significance
Age by result	Positive: median 20 years (IQR 5-36)	Negative: median 19 years (IQR 6.75-41.25)	Mann-Whitney U	U = 1284.5	0.587	NS
Age by sex among positive records	Female: median 12 years (IQR 4-26)	Male: median 25 years (IQR 6-38.5)	Mann-Whitney U	U = 2865.5	0.033	*

In accordance with the categorical distribution of positive records by age, the difference between positives with female and male genders does indicate an age differential in two different ways. For instance, female positive records are concentrated much more heavily in the younger age groups (under 25), but conversely, there is a larger proportion of males in the adult age ranges than there is of females. This further demonstrates that the difference between the sexes is not simply a matter of one sex having a much larger positive group than the other, although that may also have some bearing on their numbers, but it also indicates that the difference is not restricted to just a single extreme in age distribution, but rather is spread throughout the distribution of the two sexes across the overall positive group. The detailed age-group composition and chi-square test are shown in Table 5.

Table 5. Age-group distribution by sex among positive cutaneous leishmaniasis records

Age group (years)	Female, n	Male, n	Total, n
<1	1	4	5
1-4	16	17	33
5-14	18	21	39
15-24	12	12	24
25-44	8	35	43
45-64	7	15	22
>=65	2	7	9

Comparing age group distribution by sex of the positive (Findings from Chi-square statistic analysis, chi-square = 13.02, Degree of freedom = 6, p-value = 0.043 = statistically significant).

The statistically significant age differences between female and male positive records suggest potential epidemiological differences in exposure patterns between sexes. Female positive records were concentrated in younger age groups, whereas males predominated within adult age categories.

These findings indicate that sex-associated epidemiological variation is distributed throughout the age spectrum rather than confined to a single age category. Such patterns may reflect occupational exposure, household transmission dynamics, healthcare-seeking behavior, or sociocultural differences influencing vector exposure within endemic communities.

Seasonal clustering was evident in the monthly distribution, with the highest counts in November and December and substantially fewer records in the warmer months. This pattern indicates a clear late-autumn and winter concentration in the recorded cases. The full monthly distribution is summarized in Table 6.

Table 6. Monthly distribution of positive cutaneous leishmaniasis records

Month	Positive records, n (%)
January	25 (14.3%)
February	22 (12.6%)
March	6 (3.4%)
April	8 (4.6%)
May	3 (1.7%)
June	0 (0.0%)
July	3 (1.7%)
August	9 (5.1%)
September	10 (5.7%)
October	19 (10.9%)
November	39 (22.3%)
December	31 (17.7%)

November-February total: 117/175 (66.9%).

To examine the temporal pattern more closely, months were combined into colder (November to February) and warmer (March to October) groups. A higher proportion of positive tests was observed in the colder months; however, this association did not reach conventional statistical significance. Thus, the finding should be interpreted as a descriptive seasonal trend rather than a statistically significant difference (p=<0.005). The relevant statistics are provided in Table 7.

Table 7. Seasonal clustering analysis

Period	Positive, n	Negative, n	Positivity within the period	Statistical test	Effect size	P value	Significance
November -February	117	7	94.4%	Fisher's exact / Pearson's chi-square	OR = 2.59 (95% CI 0.92-7.31)	0.005 / 0.114	dagger
March-October	58	9	86.6%				

When looking at the epidemiological signal from the Mosul study, we observed that cutaneous leishmaniasis occurrences were not being widely distributed across all locations and times, but instead were accumulating within a small subset of location titles (i.e., area names), with clusters forming mostly during the late fall and winter months. This pattern agrees with what we see when looking at Old World cutaneous leishmaniasis's microfocal transmission characteristics, where transmission in the local community is influenced by a small number of inherent risk factors (such as vector abundance, host/ animal proximity to a house, general housing conditions, proximity to other homes, and human mobility) [4, 8,10,17-21].

Biological reasonableness supports a seasonal cycle. Temporal separation resulting from sand-fly activity, reservoir contact, lesion incubation, and delayed clinical presentation all contribute to the time lapse between infection and hospital admission. Previous studies from Iraq have noted winter peaks (with maxima occurring in December, January, or February). Of the positive cases in this analysis, 66.9% were reported from the months of November through February, and the two months with the highest case totals were November and December. Seasonal comparisons did not meet $p < 0.05$, but the direction of the effect remained clear, while the small number of negative cases in both groups limits the inferential power [9,10,28-30].

From the address data, we determined a somewhat focal distribution of positive records. A limited number of localities contributed a sizeable proportion of the overall positive burden, indicating that cutaneous leishmaniasis, as recorded by the hospital, did not have a spatially diffuse distribution throughout the entire catchment area. This clustering of localities represents the strongest epidemiologic signal in the database and suggests that there is geographically concentrated transmission or referral burden for the disease. The leading contributing localities are listed in Table 8.

Table 8. Leading localities contributing positive cutaneous leishmaniasis records

Locality	Positive records, n (%)
Muhalbia	30 (17.1%)
Alshoora	22 (12.6%)
Hamamali	15 (8.6%)
Qaeera	13 (7.4%)
Talabta	13 (7.4%)
Wadyhajer	8 (4.6%)
Hmeedat	5 (2.9%)
Rajmhadid	5 (2.9%)
Senjar	5 (2.9%)
Aloboor	4 (2.3%)

Geographically, the distribution of leishmaniasis in Iraq is heterogeneous. Northern governorates, including Nineveh (Mosul), Salah Al-Din, Kirkuk, and Diyala, consistently report high disease burdens. The ecological characteristics of these regions, including moderate rainfall, agricultural activities, irrigation systems, and suitable habitats for Phlebotomus sand flies, provide favorable conditions for parasite transmission. WHO reports specifically identify northern Iraq, particularly Mosul Province, as an important focus for zoonotic cutaneous leishmaniasis caused by L. major, with Phlebotomus papatasi serving as the principal vector [31,32].

4. Conclusion

The current hospital analysis indicates that cutaneous leishmaniasis records in Mosul exhibit a pronounced concentration by both temporal and geographic factors. The primary characteristics of the data have clear seasonal (late fall/winter) clustering, and a high volume of cases reporting from a small number of localities (neighbourhoods) with equal amounts of disease in both adult and paediatric ages. Female positive cases were, on average, younger than male positive cases; however, the overall prevalence of positive case status within the sample population was equal by sex. These findings support surveillance and control strategies that are geographically focused and provide a defensible framework for future patient-level molecular and geospatial research.

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التركيز المكاني والتجمع الموسمي لداء الليشمانيات الجلدي في الموصل، العراق: تحليل استرجاعي قائم على بيانات المرضى

الملخص

لا يزال داء الليشمانيات الجلدي يمثل مشكلة صحية عامة رئيسية في العراق، مع تأثيرات محتملة تشمل البيئة المحلية، وبيئة النواقل، والتغيرات البيئية، والهجرة البشرية، والسفر. راجعنا 191 سجلاً طبياً في مستشفى الموصل العام للفترة 2025-2026، والتي اعتُبرت مناسبة للتحليل. شملت المتغيرات المتاحة الجنس، والعمر، ونتيجة التشخيص، والتاريخ، والعنوان. استند التشخيص في الممارسة الروتينية إلى مسحة الآفة بالإضافة إلى التقييم السريري والمخبري. لُخِّصت المتغيرات الفئوية على شكل ترددات ونسب مئوية. وُصِف العمر بالمتوسط، والانحراف المعياري، والوسيط، والمدى الربيعي، والمدى. أُجريت مقارنات المجموعات باستخدام اختبار مربع كاي لبيرسون أو اختبار فيشر الدقيق للمتغيرات الفئوية، واختبار مان-ويتني يو للعمر. تم حساب نسب الأرجحية (ORs) مع فترات ثقة 95 (CIs) %لمقارنات 2 2x مختارة. من بين 191 سجلاً، كانت 175 منها إيجابية و16 سلبية، مما أسفر عن نسبة إيجابية بلغت 91.6% (فترة ثقة 95%، 86.8%-94.8%). كانت غالبية السجلات الإيجابية من الذكور (63.4%)، ولكن لم يختلف معدل الإيجابية اختلافًا كبيرًا بين الجنسين ضمن عينة المرضى في المستشفى (اختبار فيشر الدقيق، p = 0.424). تراوحت أعمار السجلات الإيجابية من 0.5 إلى 75 عامًا، بمتوسط 23.3 ± 20.2 عامًا ووسيط 20 عامًا (المدى الربيعي، 5-36). كانت الفئة العمرية الأكبر هي 25-44 عامًا (24.6%)، تليها الفئة 5-14 عامًا (22.3%) ثم الفئة 1-4 أعوام (18.9%). كانت متوسطات عمر الإناث المصابات أقل من متوسطات عمر الذكور (12 عامًا مقابل 25 عامًا؛ اختبار مان-ويتني U ، قيمة p = 0.033).

تركزت الحالات الإيجابية في الفترة من نوفمبر إلى فبراير (66.9%)، مع ذروة في نوفمبر وديسمبر. عند دمج الأشهر في فئتين: نوفمبر-فبراير مقابل مارس-أكتوبر، لوحظت نسبة أعلى من الحالات الإيجابية في الأشهر الأبرد (نسبة الأرجحية، 2.59؛ فاصل الثقة 95%، 0.92-7.31)، على الرغم من أن هذا لم يصل إلى مستوى الدلالة الإحصائية الرسمية (اختبار فيشر الدقيق، قيمة .(0.005 > p على مستوى المناطق، شكلت مناطق المهلبية والشورة والحمامالي والقيرة وطلبتا 53.1% من إجمالي الحالات الإيجابية. أظهرت هذه النتائج توزيعًا بؤريًا واضحًا لحالات داء الليشمانيات الجلدي زمانيًا ومكانيًا. تدعم هذه النتائج المراقبة والسيطرة الموجهة جغرافيًا ضمن نطاق اختصاص المستشفى، مع التأكيد على محدودية بيانات سجلات المستشفى في تقدير معدل الإصابة على مستوى السكان.

الكلمات المفتاحية : داء الليشمانيات الجلدي، علم الأوبئة في المستشفيات؛الموسمية؛ التركيز المحلي؛ التشخيص بالمسحة.