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ABSTRACT

Leishmaniases are among the most neglected vector-borne diseases, affecting humans as well as a wide range of animal hosts, with clinical manifestations ranging from cutaneous lesions to severe, life-threatening visceral forms. A retrospective study on cutaneous leishmaniasis (CL) and visceral leishmaniasis (VL) was conducted in the province of Setif to assess the current epidemiological situation of these diseases in the region. In addition, environmental factors that may influence the spatial distribution of the disease were analysed using Geographic Information Systems (GIS). Data were obtained from the Direction of Health and Population of Setif, and ArcGIS 10.8 software was used to map notified cases and evaluate selected environmental factors. A total of 295 CL cases and 10 VL cases were reported during the study period. The highest incidence of CL was recorded in 2017 (63 cases), whereas VL peaked in 2016 (3 cases). The annual evolution of the disease showed both decreasing and increasing trends over the study period. Cases were reported throughout the year, with CL exhibiting a higher incidence during winter, particularly in November (73 cases), while VL peaked in March (3 cases). CL affected both sexes and all age groups, with a predominance among males (196 cases) and adults aged 20-40 years. In contrast, VL mainly affected children under 9 years of age and occurred equally in both sexes. Spatial analysis revealed a high endemicity of CL in the southern part of the province, particularly in the municipalities of Ain Oulmene and Ain Azel, which recorded the highest disease burden, with more than 30 reported cases each. In contrast, VL cases were more randomly distributed, with the municipality of Setif reporting the highest number of cases (3 cases). The analysis of environmental factors revealed higher incidences of CL and VL in areas characterized by an altitude below 1,200 m, slopes of less than 4°, a Normalized Difference Vegetation Index below 0.30, an average annual temperature ranging from 14.5°C to 15.5°C, a land surface temperature below 27°C, a relative humidity below 64%, and annual precipitation below 500 mm for CL and below 600 mm for VL.

Keywords: Epidemiology, Cutaneous leishmaniasis, Visceral leishmaniasis, Environmental factors, Climatic factors, Geographic information system, Setif.

RÉSUMÉ

Les leishmanioses figurent parmi les maladies à transmission vectorielle les plus négligées, touchant aussi bien l'être humain qu'un large éventail d'hôtes animaux, avec des manifestations cliniques allant des lésions cutanées aux formes viscérales graves et potentiellement mortelles. Une étude rétrospective sur la leishmaniose cutanée (LC) et la leishmaniose viscérale (LV) a été menée dans la wilaya de Sétif afin d'évaluer la situation épidémiologique actuelle de ces maladies dans cette région. En outre, les facteurs environnementaux susceptibles d'influencer la répartition spatiale de la maladie ont été analysés à l'aide des systèmes d'information géographique (SIG). Les données ont été obtenues auprès de la Direction de la Santé et de la Population de Sétif, et le logiciel ArcGIS 10.8 a été utilisé pour cartographier les cas notifiés et évaluer certains facteurs environnementaux sélectionnés. Au total, 295 cas de LC et 10 cas de LV ont été enregistrés au cours de la période d'étude. L'incidence la plus élevée de la LC a été observée en 2017 (63 cas), tandis que la LV a atteint son pic en 2016 (3 cas). L'évolution annuelle de la maladie a montré des tendances à la fois décroissantes et croissantes au cours de la période étudiée. Des cas ont été signalés tout au long de l'année, la LC présentant une incidence plus élevée en hiver, particulièrement au mois de novembre (73 cas), tandis que la LV a atteint son maximum au mois de mars (3 cas). La LC a touché les deux sexes et toutes les tranches d'âge, avec une prédominance chez les hommes (196 cas) et les adultes âgés de 20 à 40 ans. En revanche, la LV a principalement affecté les enfants de moins de 9 ans et a touché les deux sexes de manière équivalente. L'analyse spatiale a révélé une forte endémicité de la LC dans la partie sud de la wilaya, notamment dans les communes d'Aïn Oulmène et d'Aïn Azel, qui ont enregistré la charge de morbidité la plus élevée, avec plus de 30 cas signalés chacune. En revanche, les cas de LV étaient répartis de manière plus aléatoire, la commune de Sétif ayant enregistré le plus grand nombre de cas (3 cas). L'analyse des facteurs environnementaux a mis en évidence des incidences plus élevées de la LC et de la LV dans les zones caractérisées par une altitude inférieure à 1 200 m, des pentes inférieures à 4°, un indice de végétation par différence normalisée (NDVI) inférieur à 0,30, une température annuelle moyenne comprise entre 14,5 °C et 15,5 °C, une température de surface terrestre (LST) inférieure à 27 °C, une humidité relative inférieure à 64 % et des précipitations annuelles inférieures à 500 mm pour la LC et à 600 mm pour la LV.

Mots-clés : Épidémiologie, leishmaniose cutanée, leishmaniose viscérale, facteurs environnementaux, facteurs climatiques, systèmes d'information géographique, Sétif.

الملخص

يعد داء الليشمانيات الذي ينتقل بواسطة النواقل أكثر أحد الأمراض المهملة، حيث يصيب البشر وكذلك العديد من الحيوانات، مع نتائج سريرية تتراوح من الاضطرابات الجلدية إلى الأمراض الحشوية والمهددة للحياة. في هذا العمل، قمنا بإجراء دراسة بأثر رجعي على داء الليشمانيات الجلدي وداء الليشمانيات الحشوي في ولاية سطيف بهدف تحديد الوضع الوبائي الحالي للمرض في هذه المنطقة. بالإضافة إلى ذلك، تم إجراء دراسة للعوامل البيئية التي قد تؤثر في التوزيع المكاني للمرض باستخدام نظام المعلومات الجغرافية .تم الحصول على البيانات من مديرية الصحة والسكان لولاية سطيف، ثم حُللت باستخدام برنامجArcGIS 10.8 لرسم خرائط الحالات المبلّغ عنها ودراسة تأثير بعض العوامل البيئية والمناخية. في المجمل تم تسجيل 295 حالة من الليشمانيا الجلدية و10 حالات من الليشمانيا الحشوية، مع أعلى معدل إصابة لليشمانيا الجلدية سنة 2017 (63 حالة)، وأعلى معدل إصابة لليشمانيات الحشوية سنة 2016 (3 حالات). أظهر التطور السنوي لليشمانيات الجلدية والحشوية اتجاهات متذبذبة من الانخفاض والارتفاع خلال فترة الدراسة. سُجلت الحالات على مدار السنة، مع ارتفاع الإصابة بالليشمانيات الجلدية خلال فصل الشتاء، خاصة في شهر نوفمبر (73 حالة)، بينما بلغت الليشمانيات الحشوية ذروتها في شهر مارس (3 حالات). أصابت الليشمانيات الجلدية كلا الجنسين وجميع الفئات العمرية، مع هيمنة واضحة لدى الذكور (196 حالة) والبالغين الذين تتراوح أعمارهم بين 20 و40 سنة، في حين أصابت الليشمانيات الحشوية بشكل رئيسي الأطفال الذين تقل أعمارهم عن 9 سنوات وكلا الجنسين بالتساوي. أظهر التحليل المكاني ارتفاع توطن الليشمانيا الجلدية في الجزء الجنوبي من الولاية، خاصة في بلديتي عين ولمان وعين أزال، اللتين سجلتا أعلى عبء للمرض، بأكثر من 30 حالة مُبلَّغ عنها في كل منهما. وعلى النقيض من ذلك، كان توزيع حالات الليشمانيا الحشوية أكثر عشوائية، حيث سجلت بلدية سطيف أكبر عدد من الحالات (3 حالات). كما كشف تحليل العوامل البيئية عن ارتفاع معدلات الإصابة بالليشمانيا الجلدية والحشوية في المناطق التي تتميز بارتفاع يقل عن 1200 متر، وانحدارات تقل عن 4 درجات، ومؤشر الغطاء النباتي المعياري (NDVI) أقل من 0.30، ومتوسط درجة حرارة سنوية يتراوح بين 14.5 و15.5 درجة مئوية، ودرجة حرارة سطح الأرض (LST) أقل من 27 درجة مئوية، ورطوبة نسبية أقل من 64%، ومعدل تساقط سنوي للأمطار أقل من 500 مم بالنسبة لليشمانيا الجلدية وأقل من 600 مم بالنسبة لليشمانيا الحشوية.

الكلمات المفتاحية: علم الأوبئة، الليشمانيا الجلدية، الليشمانيا الحشوية، العوامل البيئية، العوامل المناخية، نظم المعلومات الجغرافية، سطيف.

Introduction

Leishmaniasis is classified as a neglected tropical disease (NTD) and represents a major group of vector-borne diseases caused by protozoan parasites of the genus *Leishmania*. These parasites are transmitted to humans and other mammals through the bites of infected female phlebotomine sand flies. The disease occurs in three principal clinical forms. Cutaneous leishmaniasis (CL), the most common form, is characterized by skin ulcers and scars that may heal spontaneously. Visceral leishmaniasis (VL), the most severe form, affects internal organs and can lead to life-threatening complications if left untreated. Mucocutaneous leishmaniasis (MCL) is characterized by the progressive destruction of the mucous membranes of the nose, mouth, and throat, resulting in severe disfigurement and functional impairment (Cosma *et al*., 2023).

Leishmaniasis remains a major public health problem worldwide, endemic in 99 countries across tropical, subtropical, and Mediterranean regions (PAHO, 2024). Approximately 350 million people are at risk, with around 12 million cases globally (Georgiadou *et al.*, 2015). In North Africa, the disease is considered a neglected and re-emerging infection (Akhoundi *et al*., 2017). Algeria is one of the most affected countries, reporting over 20,000 cases annually and ranking among the nations with the highest incidence of CL worldwide (Alvar *et al*., 2012; Ruiz-Postigo *et al*., 2021). Between 1982 and 2017, 252,659 CL cases were recorded (Benikhlef *et al*., 2021). CL is endemic in 41 Algerian wilayas, mainly in arid and semi-arid regions, whereas VL occurs primarily in the humid and sub-humid northern areas. Although less common, VL remains a serious health threat because it can be fatal if untreated (Izri *et al*., 2021). The persistence and expansion of leishmaniasis are influenced by environmental changes, urbanization, human migration, and limited control measures. Its epidemiology is further complicated by the involvement of multiple *Leishmania* species, reservoir hosts, and sand fly vectors, creating diverse transmission cycles that hinder effective disease control (Boubidi *et al*., 2011).

Leishmaniasis exhibits a heterogeneous distribution, with endemicity varying considerably between regions under the influence of environmental and climatic factors. Geographic Information Systems (GIS) are among the most valuable epidemiological tools for identifying areas at high risk of disease transmission and for assessing the relationship between reported cases and environmental determinants. GIS is widely used for disease mapping, spatial analysis, and the modelling of leishmaniasis risk factors (Palaniyandi *et al*., 2012). In addition,

GIS and Remote Sensing (RS) technologies facilitate the investigation of associations between disease distribution and various environmental and climatic variables, including rainfall, temperature, humidity, vegetation cover, and population density. By generating accurate epidemiological maps that illustrate the geographical distribution of cases, these tools have enhanced our understanding of the epidemiological characteristics of leishmaniasis and enabled more precise analyses of its spatial and temporal dynamics (Shirzadi *et al*., 2019).

In Setif Province, leishmaniasis remains a major public health concern due to the persistent occurrence of cases and the coexistence of multiple clinical forms of the disease. The province is characterized by considerable geographical and climatic diversity, encompassing both semi-arid and semi-humid zones. Recent epidemiological studies have highlighted spatial and temporal variations in case distribution, reflecting the influence of climatic, environmental, and demographic factors on disease transmission dynamics (Benikhlef *et al*., 2021; Eddaikra *et al*., 2025). Furthermore, the region provides favourable environmental and climatic conditions for the proliferation of phlebotomine sand flies, the vectors of *Leishmania* parasites, particularly in agricultural and semi-arid areas. Therefore, a comprehensive understanding of these epidemiological patterns is essential for improving surveillance systems and developing more effective prevention and control strategies in the region.

The aim of this study was to investigate the current status of CL and VL in Setif province and to characterize their epidemiological profile based on case notifications recorded between 2016 and 2025. In addition, the influence of selected climatic and environmental factors on the spatial distribution of the disease was examined.

This work is organized into three main chapters:

The first chapter presents a bibliographic review covering the essential aspects of leishmaniasis, including its clinical forms, causative agents, vectors, reservoir hosts, geographic distribution, control measures, and the application of GIS in disease surveillance.

The second chapter is devoted to the presentation of the study area and provides a detailed description of the materials and methods used in the study.

The third chapter presents and discusses the results obtained.

Finally, a general conclusion is provided, highlighting new insights and suggesting future research directions to improve our understanding of the epidemiology of leishmaniasis in Algeria and in the study area.