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RESEARCH ARTICLE

Epidemiological and entomological aspects of cutaneous leishmaniasis in Saudi Arabia: A narrative review

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ABSTRACT

Leishmaniasis is an infectious disease caused by protozoan parasites of the genus *Leishmania*, transmitted through the bite of infected female *phlebotomine* sandflies. As a neglected tropical disease, it has recently garnered significant attention. Cutaneous leishmaniasis (CL) is a priority for disease control by the World Health Organization (WHO) in Saudi Arabia, among other countries. This narrative review focuses on the history of the disease, its epidemiological and entomological aspects, high-risk populations, and hard-to-reach areas. The review is based on a comprehensive analysis of literature published in English on leishmaniasis in Saudi Arabia. Articles were systematically filtered to ensure relevance to the scope of this paper. Findings from these studies were summarized and categorized geographically into five main regions: Northern, Southern, Eastern, Western, and Central Saudi Arabia.

Keywords: Leishmaniasis; Saudi Arabia; epidemiology.

INTRODUCTION

Leishmaniasis is a neglected tropical disease caused by protozoan parasites of the genus *Leishmania*, with over 20 species known to infect humans. The disease is transmitted through the bite of infected female *phlebotomine* sandflies, tiny insect vectors measuring 2–3 mm in length (WHO, 2023). Leishmaniasis manifests in three primary forms: cutaneous leishmaniasis (CL), visceral leishmaniasis (VL), also known as kala-azar, and mucocutaneous leishmaniasis (MCL). Among these, CL is the most common, VL is the most severe, and MCL is the most disabling form of the disease (WHO, 2023). CL, in particular, is a potentially disfiguring condition that can lead to significant social stigmatization (Abuzaid *et al*., 2019).

In Saudi Arabia, two forms of leishmaniasis are prevalent: cutaneous and visceral leishmaniasis, with the latter being less frequently reported. Between 2007 and 2017, sporadic cases were reported annually, primarily confined to the southwestern regions of Jazan and Aseer (Abuzaid *et al*., 2017). Additionally, a rare case of primary mucosal leishmaniasis (PML) involving the mucosa of the post-nasal space, maxillary sinuses, larynx, and trachea has been documented (Al-Qahtani *et al*., 2012).

This narrative review aims to comprehensively examine the literature on cutaneous leishmaniasis in Saudi Arabia, with a focus on the disease's history, epidemiological patterns, high-risk populations, hard-to-reach areas, and entomological perspectives.

MATERIALS AND METHODS

The data presented in this review were gathered through an extensive literature search conducted on PubMed and Google Scholar using the search terms "Leishmaniasis" and "Saudi Arabia." This search yielded over 450 articles, which were subsequently filtered to ensure relevance to the scope of this review. Duplicate studies and irrelevant papers were excluded. This narrative review summarizes the key findings of research conducted locally on cutaneous leishmaniasis in Saudi Arabia.

RESULTS

History of Cutaneous Leishmaniasis

CL has been recognized since ancient times. In the 18th century, it was described as a specific ulcerating granuloma of the skin, endemic in warm regions, including Arabia. Historically, the disease was named after towns or districts where it was prevalent, such as "Delhi boil" or "Baghdad boil," though the term "Oriental sore" was widely used (Manson, 1898). Arab physicians, including Avicenna in the 10th century, had previously described the condition, referring to it as the "Balkh sore" (Ul Bari, 2006).

The first case of CL in Saudi Arabia was reported in the eastern region during the early 1950s by the Aramco Medical Department. The patient was believed to have acquired the infection outside the eastern province, as locally acquired cases were not detected until 1970 (Al-Shammari *et al*., 1993).

CL was historically underreported in Saudi Arabia and was considered a minor public health concern until 1975 (Ahmed Zakai, 2014). However, by 1973, the disease had reached epidemic proportions (Al-Tawfiq & Abukhamsin, 2004). In response, Saudi health authorities mandated the notification of all leishmaniasis cases to the Ministry of Health (May, 2005).

The first case of mucocutaneous leishmaniasis in Saudi Arabia was reported in 1980 in a 5-month-old Saudi boy admitted to Dammam Central Hospital in the Eastern Province. The infection,

caused by *Leishmania major*, manifested as extensive lesions on the nose and right cheek. The patient was successfully treated with sodium stibogluconate, resulting in complete healing (Al-Gindan & Al-Humaidan, 1983).

Saudi Arabia is among the top 10 endemic countries for CL globally. A 1996 report identified the Kingdom as one of six countries accounting for 90% of global CL cases (Desjeux, 1996). Locally, CL is known by various names, including *dommal*, *nafra*, and *El-mohtafara* (Knight *et al*., 2023).

The registration of CL cases revealed a significant increase from 1,043 cases in 1978 to 16,611 cases in 1986 across all regions of Saudi Arabia. This surge was attributed to improved case diagnosis and reporting following the establishment of a leishmaniasis unit by the Ministry of Health and the implementation of a mandatory reporting system in all provinces (Al-Zahrani, 1988; Al-Zahrani *et al*., 1989).

The Saudi Ministry of Health launched a leishmaniasis control program in 1978, which led to a dramatic decline in reported cases from over 13,000 in 1983 to fewer than 2,000 in 2015 (Abuzaid *et al*., 2017). From 2006 to 2015, the regional distribution of cases remained relatively stable, with the exception of the Makkah region, which became CL-free by 2015, and Al-Jouf, which reported cases starting in 2013. The most endemic regions during this period were Al-Hassa, Madinah, Hail, and Al-Qaseem (Abuzaid *et al*., 2017). However, the true incidence of CL is believed to be underestimated, as not all cases seek medical attention or are reported to public health authorities (Abuzaid *et al*., 2019).

In 1982, the Saudi authorities established the National Leishmaniasis Research Program (NLRP) under the supervision of the Saudi Arabian National Council for Science and Technology (SANCST), now known as King Abdulaziz City for Science and Technology (KACST). The program, based at the Faculty of Medicine, King Faisal University, Dammam, aimed to conduct an in-depth evaluation of the clinical and epidemiological aspects of leishmaniasis in Saudi Arabia and to develop optimal strategies for its elimination (Peters *et al*., 1985). Peters *et al*. (1986) studied *Leishmania* parasites in Saudi Arabia and identified a distinct species, *Leishmania arabica*, based on differences in isoenzyme characteristics and kinetoplast DNA compared to other global species. *Phlebotomus papatasi* was identified as the vector for *L. arabica*. Subsequent research suggested that *L. arabica* could potentially induce partial cross-protection against *L. major* due to its low virulence (Neal *et al*., 1990).

In the Eastern Province, 1,255 CL cases were reported between 1956 and 1991, followed by an additional 607 cases in the subsequent decade. No recurrent cases were observed among these patients. The annual number of cases increased significantly over time, from five cases in the 1950s–1960s to 80 cases in the 1970s–1980s and 50 cases per year in the 1990s. Although 120 cases were reported in 1996, the incidence stabilized at approximately 20–40 cases per 100,000 population after 1987 (Al-Tawfiq & Abukhamsin, 2004).

Key result 1

Cutaneous leishmaniasis (CL) has long been documented as an endemic disease in warm regions, including Saudi Arabia. The first recorded cases in the country were identified in the 1950s, with a significant outbreak in 1973 leading to epidemic levels. This prompted the establishment of control programs by the Ministry of Health, including mandatory case reporting initiated in 1978. These efforts led to a decline in reported cases from over 13,000 in 1983 to fewer than 2,000 by 2015. Notably, *Leishmania arabica*, a new species specific to the region, was discovered during this period, with *Phlebotomus papatasi* identified as its vector. Figure 1 summarizes the key milestones of CL in Saudi Arabia.

Epidemiology of Cutaneous Leishmaniasis in Saudi Arabia

Cutaneous leishmaniasis in Saudi Arabia is classified into two types based on transmission patterns: anthroponotic cutaneous leishmaniasis (ACL), transmitted from human to human and caused by *Leishmania tropica*, and zoonotic cutaneous leishmaniasis (ZCL), transmitted from animals to humans and caused by *Leishmania major* (Alraey *et al*., 2022).

Geographical Distribution: *L. major* (ZCL) is widely distributed but predominantly found in the central and eastern regions of Saudi Arabia. In contrast, *L. tropica* (ACL) is primarily reported in the southwestern regions, though recent studies have identified its presence in other areas as well. Both species coexist in regions such as Al-Qaseem, Al-Madina Al-Munawarah, Al-Taif, and Al-Baha (Abuzaid *et al*., 2019). Table 1 illustrates the geographical distribution according to regions of Saudi Arabia.

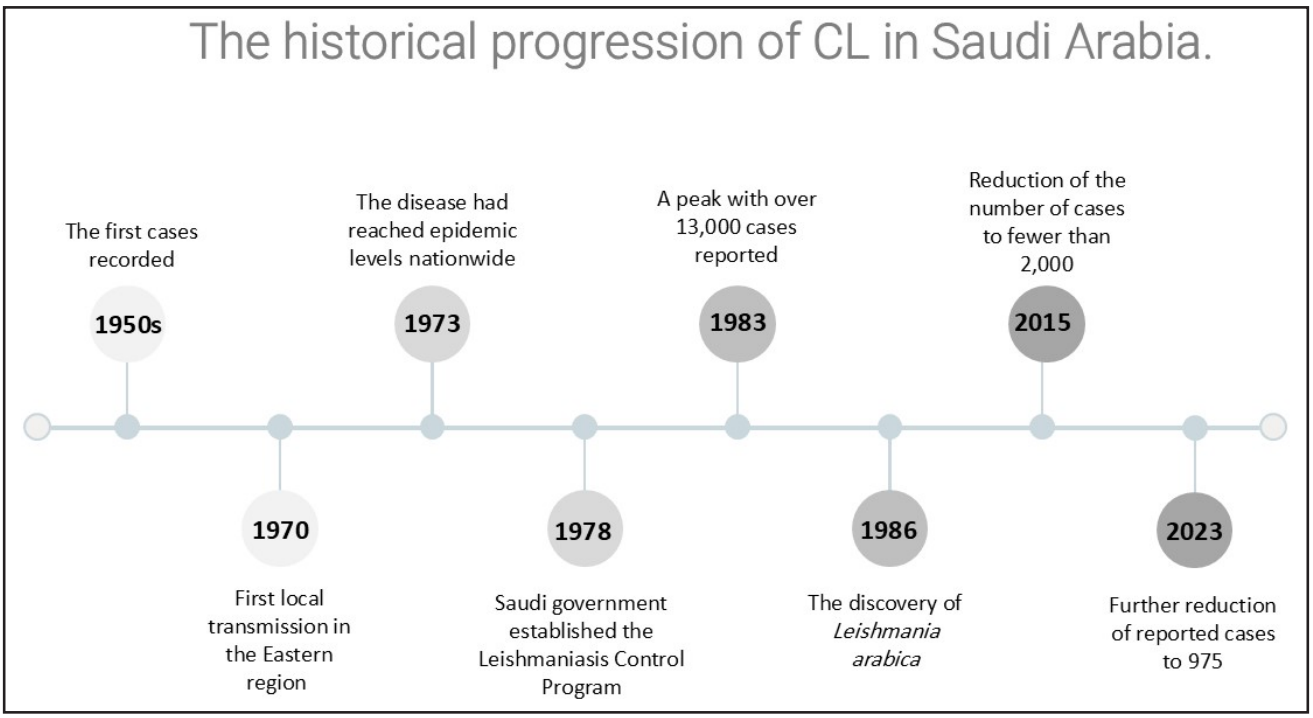

Figure 1. The historical progression of CL in Saudi Arabia.

Table 1. Studies according to the geographical distribution of the Kingdom of Saudi Arabia

	Region	Author	Study duration	Sample size	Sample characteristics	Main findings
Central Saudi Arabia	Al-Kharj	Mahmoud *et al*. (1984)	October 1981 and June 1983	413	Patients with skin ulcers and diagnosed with CL.	Most cases were recorded from October to January. Also, most patients were non-Saudis, with *Rattus rattus* being the most likely reservoir.
	Riyadh	Hossain *et al*. (1988)	November–May 1988	826	Patients diagnosed with CL attending dermatology clinic.	The main leishmania parasite detected was L. *tropica.*
	Riyadh	Al-Shammari *et al*. (1993)	between 1987 and 1990	11 802	Patients diagnosed with CL.	Decline in disease incidence: Most patients were between 15 and 44 years old, and most cases occurred during winter.
	Ad-Dawadimi	Alanazi *et al*. (2016)	January 2009 to December 2013	370	Data were collected from the Leishmaniasis Control Center.	The prevalence of CL dropped from 1.68 per 10 000 in 2010 to 0.42 per 10 000 in 2012, with 75.6% of patients being male.
	AL Majmaah	Barradah (2017)	2007–2016	87	Data on cutaneous leishmaniasis patients was obtained from the regional vector control unit.	The incidence of the disease was 33 per 100,000 in 2007 and peaked at 44 per 100,000 in 2008, then started to decline to 4 per 100,000 in 2016. Patients aged between 15 and 44 years represented 50.6%, males constituted 78.2%, Saudis were 62.1%, and farming had the highest proportion among other occupations, which is 28.7%.
	Riyadh	Alanazi *et al.* (2019)	March 2016 to July 2018	237	Survey of canine leishmaniasis.	The analysis showed that nine dogs were positive for Leishmania *major*.
	Riyadh, Al-Ahsa, and Al-Qaseem	Alanazi *et al.* (2019)	March 2016 to April 2018	526	Stray dogs.	PCR revealed that 31 (5.9%) dogs were positive for the genus Leishmania. Further investigations indicated that Al-Ahsa was the most endemic area, followed by Al-Qaseem.
	Al-Qassem	Rasheed *et al*. (2019)	2019	206	Patients diagnosed microscopically with CL attending a dermatology clinic.	Most of the patients were male; 49.5% were found to be positive for *L. major,* and 28.6% were positive for *L. tropica.*
	Riyadh and Al-Qassem	Alanazi *et al*. (2021)	January 2018 to May 2019	311 stray dogs and 27 humans.	Humans and stray dogs are suspected to have CL.	31.2% of human subjects were positive for Leishmania. Further analysis confirmed the presence of *L. major* in Riyadh and *L. tropica* in Al-Qaseem. Five dogs were positive for *L. tropica*.

The eastern regions of Saudi Arabia	Hofuf	Al Gendan Yousef *et al*. (1984)	1979 (for 4 months)	122	Patients with CL.	46% of patients were Saudis, and 66% of Saudi patients were younger than 10 years.
	Al Hassa	Dye *et al*. (1989)	July 1982–December 1983	2008	Zoonotic cutaneous leishmaniasis patients.	The proportion of males with CL was higher than that of females, and the age distribution was clearly bimodal, with a sharp decline between 3 and 15 years.
	Al Hassa and Sudan	Gaafar *et al*. (1994)	1994	177 in Sudan and 100 in ALHassa	Sporotrichoid cutaneous leishmaniasis in Al Hasa compared to Sudan.	Most patients were males in Al Hassa, whereas almost half were males in Sudan.
	Al Hassa	Amin *et al*. (2013)	2000–2010	9 962	Patients with CL.	The incidence rate declined from 243 to 40 per 100,000 in 2000 and 2010, respectively, with male dominance. CL cases were mainly reported in the age group between 15 and 45 years, peak of cases was observed during January and February.
	Al Hassa	Kubba *et al*. (1987)	2014	475	Patients with CL.	Children aged below 10 years represent 52% of cases, *and L. major* is the main parasite.
	Al Hassa	Al-Rashed *et al*. (2022)	2022	98	Patients with CL confirmed by PCR.	*L. major* was identified in 96.9% of patients, unexpectedly in Al-Ahsa, *and L. tropica* was identified in three patients. Males comprised the majority of patients, and most of those lived in rural areas (98%). In terms of age group, 61% of patients with CL were aged 15–44 years.
Northern Saudi Arabia	Hail	Haouas *et al*. (2015)	from 2010 to 2013	483	Patients diagnosed with CL attending dermatology clinic.	Males constituted 70.6% of the cases, and the majority were of Saudi nationality. 68.32% occurred in the 15-year-old group. The peak cases were observed in February and March.
	Tabuk	Hassanein *et al*. (2023)	January 2006 and December 2021	1 575	Patients diagnosed with CL.	The number of CL cases ranged from 42 to 165 patients/year. Recently, most cases were non-Saudis, and in the age group of 15–45, the highest numbers were reported in January and February.
Western Saudi Arabia	Taif	Khan & Zakai (2014)	2013	47	Suspected cases of CL.	27 individuals were found to be positive. Seventeen isolates were identified as *L. major*, and 10 were identified as *L. tropica*. 70% were male, and adults aged from 40 to 60 years suffered the most.
	Al-Madinah Almonawra	Abdalla *et al*. (2019)	March 2014 to March 2015	164	All patients with CL attending healthcare facilities are male.	Patients aged 21–30 years were 78, representing 47.9%
	Al-Madinah Almonawra	Elmekki *et al*. (2017)	January 2012 and March 2015	467	Participants diagnosed with CL.	The majority were Saudi nationals (68.7%, males dominating the patients by 86.9%, the 21–30 years age group constitutes the highest proportion, geographically, northern area had the highest number of infected individuals
	Al-Madinah Almonawra	El-Beshbishy *et al*. (2013)	2013	34	Patients with CL.	The causative organisms are *L. major* and *L. tropica.*

The southern regions of Saudi Arabia	Asir, Al-Baha, and Jizan	Al-Zahrani *et al.* (1989)	1989	44	Isolates from patients with CL.	Cases began to increase in October and reached a peak in December. Most cases were caused by L. *tropica*, whereas the minority were caused by L. *major*.
	Jazan (Faifa)	Raghu (1998)	1988 and 1990	2 500	Patients who visited a dermatology clinic with various skin lesions.	140 new cases were diagnosed with CL, most of them were Saudis, with the majority being aged below 50 years.
	Abha	Malik (1991)	1991 (for 2 months)	34	Patients with cutaneous leishmaniasis.	Almost 85% were Saudis, and most of the cases (94%). Most Saudi patients (70.6%) are aged between 5 and 20 years, and cases are rare in the elderly local population.
	Al Majardah	Harjeet & Sekaran (1993)	1993 (for 1 month)	15	Patients diagnosed with CL attending dermatology clinic.	Approximately 66% of the cases involved children younger than 13 years.
	Asir	Faraj & Lake (2015)	January 1996 to December 2007	-	Data on cases and weather data in Asir region.	Temperature was the single most important factor associated with CL in all areas of Asir and in the highlands during the summer and beginning of autumn. In the lowlands, more cases occurred if rainfall was high in the previous 1 to 3 months.
	AL Baha and Al Qassem	Shalaby *et al.* (2011)	2008	50	Human samples of skin ulcers.	Thirty six samples were positive for the presence of Leishmania species, 25 were *L. major*, and 11 were *L. tropical.*
	Al Baha	Khairy & Alhussainy (2014)	January and December in 2012 and 2013	16	New cases of CL.	The incidence rate was (4.4/ 100 000) in 2012 and 2/100,000 individuals in 2013.
	Jizan	Makeen *et al.* (2018)	January 2012 and December 2015	43	Patients with parasitologically confirmed CL who visited the dermatology clinic.	Males accounted for the majority of cases (65.1%); also, 60.5% of samples were for pediatric patients.
	Jizan	Noureldin *et al.* (2018)	2007–2015	390	Patients diagnosed with CL.	The majority of the cases 64% were males. Interestingly, almost 99% of the cases were Saudi, with the age group older than 15 years being the main affected age group, spatially, Aledabi had the highest number.
	Asir	Alraey *et al.* (2022)	January–December 2021	194	Patients diagnosed with CL.	About 87% of CL patients came from two main governorates, Khamis-Mushait and Abha. Males comprised 62.3%, mostly Saudis, 90.7%, patients under 13 years of age comprised 38.1%, 183 patients were positive for *L. tropica*, and five patients showed positive results for *L. major.*
	Asir	Alraey (2022)	2011-2020	1 565	Patients diagnosed with CL.	The prevalence of CL was higher in males than in females, and Saudi citizens were more likely to suffer from CL. Children aged 0-12 years consistently had the highest number of CL cases, and Abha recorded the highest incidence rate of 188 cases per 100 000 people.
	Najran (Hubuna)	Alzahrani *et al.* (2023)	January–October 2022	391	Participants surveyed.	CL was self-reported to be 38.1%, males were 41.1%, and children (0–10 years) were 76% of the CL cases.

Reservoirs and Vectors: The primary vectors of CL in Saudi Arabia are *Phlebotomus papatasi* (vector of *L. major*) and *Phlebotomus sergenti* (vector of *L. tropica*). The main reservoir hosts are two rodent species: *Psammomys obesus* and *Meriones libycus*. Zoonotic transmission has also been documented for *L. tropica* (Postigo, 2010; Abuzaid *et al*., 2019).

Seasonal Variation: CL exhibits clear seasonality, with cases increasing in September, peaking in January and February, and declining to their lowest levels between April and July. The highest number of cases is typically reported in winter and spring, with December (13%), February (9.7%), and January (8.9%) being the most affected months. Conversely, the lowest numbers are observed in August (6.2%) and June (6.4%) (Abuzaid *et al*., 2017; Alraey, 2022).

Demographic Patterns: CL is more prevalent in males, with some studies reporting a male-to-female ratio of 4.9:1 (Hassanein *et al*., 2023). However, other studies suggest a more balanced distribution, with a ratio of 1.1:1 (Al-Tawfiq & Abukhamsin, 2004). Adults account for the majority of cases (66.2%), though some studies report a higher prevalence among individuals under 15 years of age (76%) (Al-Shammari *et al*., 1993; Ahmed Zakai, 2014; Abass *et al*., 2020).

Factors Contributing to the Increase in CL Transmission in Saudi Arabia

Several factors have contributed to the rise in cutaneous leishmaniasis (CL) transmission in Saudi Arabia, including rapid urbanization, migration, intensive agricultural practices, poor living conditions on farms, and large-scale immigration. Following the implementation of the national control program, the number of reported CL cases decreased significantly. However, certain regions in Saudi Arabia remain endemic for the disease, highlighting the persistent challenges in achieving complete control (Ahmed Zakai, 2014; Abuzaid *et al*., 2017; Alraey, 2022; Kumosani *et al*., 2022).

One key factor driving CL transmission is the migration of non-immune individuals into endemic areas. This movement increases the susceptible population, facilitating the spread of the disease (Knight *et al*., 2023). Additionally, man-made environmental changes, such as the construction of water dams, irrigation systems, and the digging of wells, have created favorable breeding conditions for sandfly vectors, further exacerbating the problem (Desjeux, 1996).

Another significant challenge is the influx of religious visitors and job seekers from countries where leishmaniasis is endemic. Saudi Arabia, as a hub for religious tourism and economic opportunities, attracts millions of individuals annually, many of whom come from regions with high leishmaniasis prevalence. This migration pattern complicates disease control efforts and underscores the need for targeted health screenings and education programs (Abuzaid *et al*., 2019).

Underreporting of CL cases also poses a major obstacle to effective disease surveillance and control. Inaccurate or incomplete data hinder the ability of public health authorities to assess the true burden of the disease and implement targeted interventions. This issue is particularly prevalent in remote areas with limited access to healthcare services and diagnostic facilities (Abuzaid *et al*., 2017, 2019).

Key Result 2

CL in Saudi Arabia is caused by two primary species: *Leishmania major* (central and eastern regions) and *Leishmania tropica* (southwestern regions). The disease exhibits clear seasonality, with cases peaking between September and February. Moreover, males, particularly those engaged in outdoor or agricultural activities, are more frequently affected, though significant cases are also reported among children in some regions. Urbanization, migration, and agricultural activities are major contributors to the sustained transmission of CL.

Key Result 3

The distribution of cutaneous leishmaniasis (CL) in Saudi Arabia varies significantly across regions. In the Central region, *Leishmania tropica* is the dominant species, with Riyadh reporting higher incidences among males and working-age adults. The Eastern region, particularly Al-Hassa, is a major hotspot for *Leishmania major*, with males in rural areas constituting the majority of cases. In the Northern region, including Hail and Tabuk, most cases are reported among non-Saudis, with peaks during the winter months. The Western region, such as Al-Madinah and Taif, exhibits co-infections of *L. major* and *L. tropica*. In the **Southern region*, endemic areas like Asir, Jazan, and Al-Baha are predominantly affected by *L. tropica*, with children and rural residents being the most affected populations (Abuzaid *et al*., 2019; Alraey, 2022).

High-risk populations and hard-to-reach areas

Certain populations are at higher risk of CL due to occupational, environmental, and immunological factors. Agricultural workers and outdoor laborers are disproportionately affected. Studies in Riyadh from 1987 to 1990 revealed that 79% of cases occurred among individuals living or working on farms, particularly in agricultural areas such as Riyadh vicinity, Al-Kharj, Shagraa, and Al-Koweeya (Al-Shammari *et al*., 1993). Non-Saudis, primarily employed as farm laborers, account for 91% of cases in some regions (Hossain *et al*., 1988; Abass *et al*., 2020).

Rural and agricultural communities also face heightened risk. In Asir province, Saudi families living near domestic animals represent the majority of rural residents, explaining the high prevalence of CL across different age groups (Alraey, 2022). Conversely, in Hail province, 74.3% of CL patients lived in urbanized areas, while 25.7% were from rural settlements (Haouas *et al*., 2015).

Children are particularly vulnerable due to their developing immune systems and increased exposure. In Al-Madinah Al-Munawarah, 34% of infected females were young children under 10 years old, who are less likely to cover their bodies and are thus more exposed to sandfly bites (Elmekki *et al*., 2017).

Environmental and behavioral factors play a significant role in CL transmission. The practice of sleeping outdoors during summer nights increases exposure to sandfly bites, contributing to infection (Al-Shammari *et al*., 1993). Plains at the periphery of cities serve as transmission foci due to the presence of sandfly vectors (*Phlebotomus papatasi*) and rodent reservoirs (*Psammomys obesus*), which provide breeding sites and blood meals for the vectors (Abuzaid *et al*., 2017).

In Tabuk, the ongoing Red Sea Project and the region's agricultural activities have attracted numerous workers from different nations, increasing the risk of CL. The region's mild climate in summer and cold, rainy winters create favorable conditions for sandfly breeding (Hassanein *et al*., 2023).

The use of bed nets and protective clothing is a critical preventive measure. Studies show that 85.4% of CL patients never used bed nets, and 83% did not use protective clothing (Abdalla *et al*., 2019).

Antibodies to sandfly saliva, such as anti-PpSP32, serve as biomarkers for disease risk. Higher levels of anti-PpSP32 antibodies were found in CL patients with active infections compared to healthy individuals. In Al-Ahsa, expatriates had significantly higher levels of anti-PpSP32 compared to local residents, with 75% of expatriates developing more than three lesions compared to 40% of locals (Mondragon-Shem *et al*., 2015). Additionally, anti-PpSP32 levels were higher in Al-Ahsa populations than in Al-Madinah, indicating greater exposure to *Ph. papatasi* bites in Al-Ahsa (Saleh & Salem, 2015).

Key Result 4

CL distribution varies by region, with *L. tropica* dominant in the Central and Southern regions and *L. major* prevalent in the Eastern region. High-risk populations include agricultural workers, outdoor laborers, migrants, and rural residents living near animal reservoirs, and children in endemic areas who are particularly vulnerable due to their developing immune systems and increased exposure. Environmental factors, such as sleeping outdoors and proximity to vector breeding sites, significantly contribute to transmission. Protective measures, including bed nets and biomarkers, are essential for disease prevention and risk assessment.

Entomological Aspects of Cutaneous Leishmaniasis Transmission in Saudi Arabia

Cutaneous leishmaniasis (CL) is a significant public health concern in Saudi Arabia, with its transmission closely tied to the distribution and activity of sandfly vectors. Various species of sandflies have been reported across the Kingdom, with 25 species identified to date, including *Phlebotomus papatasi* (Haouas *et al*., 2017). These vectors play a critical role in the transmission cycle of *Leishmania* parasites, the causative agents of CL.

An entomological survey conducted in the Al-Hassa region in 1983 captured 802 sandflies, of which 701 were identified as *P. papatasi*, widely distributed across the southern and eastern parts of the region. The remaining 108 specimens comprised three species of *Sergentomyia*: *S. antennata* (73 specimens), *S. clydei* (33 specimens), and *S. fallax* (2 specimens). Notably, promastigotes were observed in the midguts of 9 out of 256 (3.5%) female *P. papatasi*, highlighting their role as potential vectors (Killick-Kendrick *et al*., 1985).

Between 1985 and 1987, a study in southwest Saudi Arabia revealed distinct distributions of sandfly species. *Phlebotomus sergenti* and *P. bergeroti* were collected from both highland and lowland areas, while *P. arabicus* was restricted to the highlands. *P. orientalis* was primarily found in the highlands, and *P. alexandri* was collected from lowlands, particularly in foothill regions. *P. papatasi*was rare in fixed stations, with most collections occurring in Bishah and Tethlith, located in the Asir plateau. In the highlands, *P. sergenti* dominated (59%), followed by *P. arabicus* (21%), *P. bergeroti*(12%), *P. orientalis* (7%), and *P. alexandri* (1%). In lowlands, *P. bergeroti* was the most abundant (85%), followed by *P. sergenti* (10%) and *P. alexandri* (3%). *P. orientalis* and *P. papatasi* were scarce, each accounting for only 1% of the catch. Environmental factors, such as heavy rainfall in August, influenced the indoor and outdoor distribution of *P. sergenti* in highlands (Al-Zahrani, 1988).

A longitudinal study conducted between December 1986 and December 1987 in southwest Saudi Arabia collected 6,797 sandflies from highland and lowland areas. Of these, 3,957 were *Phlebotomus* species, and 2,840 were *Sergentomyia* species. *P. sergenti* and *P. bergeroti* were common in both regions, while *P. orientalis*, *P. papatasi*, and *P. alexandri* were less abundant. *P. arabicus* was confined to highlands. *P. sergenti* dominated highland catches (59%), whereas *P. bergeroti* was predominant in lowlands (85%) (Al-Zahrani *et al*., 1997). These findings align with reports from the Asir plateau, where *P. sergenti* was found infected with *L. tropica*, the primary parasite in the region (Al-Zahrani *et al*., 1988).

In the Riyadh region, a 1994 study collected 2,329 female sandflies, of which 99% were *P. papatasi* and 1% were *P. sergenti*. A dissection of 488 *P. papatasi* and 24 *P. sergenti* revealed that 11 *P. papatasi* (2.3%) were infected with *Leishmania* (Mustafa *et al*., 1994). Similarly, a 1995 survey in the Al-Baha region identified nine sandfly species, with *P. bergeroti* being the most abundant (54.4%). Seasonal activity varied, with peak densities observed between May and November (Doha, 2009). A subsequent study in Al-Baha from 1996 to 1997 confirmed *P. bergeroti* as the dominant species (41.7%), with seasonal peaks in activity from May to September (Doha & Samy, 2010).

In the Asir region, a survey from 1999 to 2001 collected 1,896 sandflies, with *P. bergeroti* constituting 85.65% of the catch. *P. sergenti* was the second most abundant species (10.97%), while *P. papatasi*, *P. orientalis*, and *P. alexandri* were rare. Seasonal activity peaked from March to September, with a significant correlation between fly density and temperature (Ibrahim & Abdoon, 2005).

A 2006–2007 survey in El-Nakheel village identified six sandfly species, with *P. papatasi* being the most dominant (73.9%). Seasonal activity peaked in June, with no *Leishmania* detected in dissected females (El-Badry *et al*., 2008). Similarly, a 2010 survey in Al-Madinah Al-Munawarah found *P. papatasi* to be the predominant species (93.8%), with 23.7% of females testing positive for *L. major* and 31% of *P. sergenti* females positive for *L. tropica* (El-Beshbishy *et al*., 2013).

Recent studies have continued to highlight the role of *P. papatasi* and *P. sergenti* as primary vectors for *L. major* and *L. tropica*, respectively. For instance, a 2012 survey in Al Ahsa and Al Madinah found *P. papatasi* to be the dominant species (99%), while *P. sergenti* was most abundant in Asir (21%) (Mondragon-Shem *et al*., 2015). Seasonal activity of *P. papatasi* is bimodal, with peaks in May–June and August (Alraey *et al*., 2022), whereas *P. sergenti* exhibits year-round activity with peaks in May and June (Alraey, 2022).

Molecular studies have further confirmed the presence of *Leishmania* in sandflies. For example, a 2015 study in Al-Madinah and Asir identified *P. papatasi* as the dominant species in Al-Madinah (97.28%) and *S. clydei* in Asir (66.37%) (Al-Dakhil *et al*., 2017). Similarly, a 2015–2016 survey in Hail Province detected *Leishmania* DNA in 6.66% of sandflies, with *P. papatasi* and *P. kazeruni* being the primary carriers (Haouas *et al*., 2017).

In Jizan, *P. sergenti* was identified as the major vector of *L. tropica* in the highlands, while *P. bergeroti* dominated lowlands (Noureldin *et al*., 2018). A 2020–2021 study in Al-Ahsa confirmed *L. major* as the only *Leishmania* species detected in sandflies (Al Rashed *et al*., 2023).

Key Result 5

The transmission of CL in Saudi Arabia is intricately linked to the distribution and seasonal activity of sandfly vectors. *P. papatasi*, the primary vector for *L. major*, is predominantly found in central and eastern regions, while *P. sergenti*, associated with *L. tropica*, is common in highlands. Seasonal peaks in sandfly activity during warmer months correlate with increased CL cases. Reservoir hosts, such as rodents (*Psammomys obesus* and *Meriones libycus*), further contribute to zoonotic transmission cycles.

DISCUSSION

This review highlights the complex and multifaceted nature of CL as a public health challenge in Saudi Arabia. The epidemiological patterns, historical trends, and entomological insights presented underscore both the progress made in controlling the disease and the ongoing challenges that hinder its elimination. This discussion synthesizes the key findings and identifies critical areas requiring further attention to advance CL control efforts.

Historically, the implementation of a structured surveillance and reporting system has significantly improved the visibility of CL cases across Saudi Arabia. Initiatives such as the National Leishmaniasis Research Program and the efforts of the Ministry of Health have played a pivotal role in reducing disease incidence over time. Despite these advancements, certain regions, including Al-Qassem, Al-Hassa, and Asir, continue to report high disease burdens. These areas remain hotspots due to environmental conditions that favor the proliferation of sandfly vectors and reservoir hosts, necessitating targeted interventions.

The geographical and seasonal distribution of CL is closely tied to the diversity and activity of sandfly species. The review emphasizes the dominance of *Phlebotomus papatasi* and *Ph. sergenti*as, the primary vectors for *Leishmania major* and *L. tropica*, respectively. Seasonal peaks in sandfly activity, particularly during the winter and spring months, coincide with increased human-vector contact, driving transmission. These findings underscore the importance of developing localized vector management strategies that account for ecological variations and seasonal dynamics.

Demographic factors also play a significant role in shaping CL prevalence. Men and outdoor workers, particularly those in agriculture or construction, face elevated risks due to prolonged exposure to sandfly habitats. Conversely, the high prevalence of CL among children in certain regions points to gaps in protective measures and highlights the need for child-focused interventions, such as education and preventive practices.

Socioeconomic factors further complicate the CL landscape. Urbanization, agricultural expansion, and migration have altered ecological dynamics, creating favorable conditions for sandfly proliferation. Migrant workers, who often lack prior exposure to CL, are disproportionately affected, underscoring the need for targeted health education and protective measures for this vulnerable group. Additionally, underreporting and limited access to healthcare services in remote areas hinders comprehensive disease control and surveillance efforts.

From an entomological perspective, the diversity of sandfly species and their adaptation to various ecological niches present ongoing challenges. Continued research into vector competence, sandfly-reservoir host interactions, and the molecular mechanisms of transmission is essential to refine control strategies. The development of biomarkers for early detection of infection risk, such as antibodies to sandfly saliva, offers promising avenues for proactive disease management and risk assessment.

Despite significant progress, achieving sustainable control of CL remains a challenge. Strengthening public awareness, enhancing surveillance systems, and addressing the social determinants of health are critical components of a comprehensive strategy. Future research should prioritize innovative vector control methods, vaccine development, and the integration of advanced molecular tools to better understand disease dynamics and transmission pathways.

CONCLUSION

In conclusion, combating cutaneous leishmaniasis in Saudi Arabia requires an integrated, multidisciplinary approach that addresses the biological, environmental, and societal factors driving disease transmission. By combining robust public health policies, scientific innovation, and community engagement, Saudi Arabia can move closer to achieving sustainable control and eventual elimination of CL. Continued collaboration between researchers, policymakers, and communities will be essential to overcome the remaining challenges and ensure long-term success in the fight against this neglected tropical disease.

Conflict of Interest

The authors declare that they have no competing interests.

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