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RESEARCH ARTICLE

Knowledge of leishmaniasis among healthcare professionals in Central Morocco: Determinants, disparities, and implications for One Health-based control

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ABSTRACT

Background and Aim: Leishmaniasis is a persistent zoonotic disease and a major public health problem in Morocco, where healthcare workers play a central role in its detection, prevention, and management. Despite national control efforts, knowledge gaps among health professionals may hinder timely diagnosis and effective surveillance. This study aimed to evaluate the level of knowledge regarding leishmaniasis among health professionals in the Marrakech–Safi region, Morocco's most endemic area, and identify factors influencing their awareness.

Materials and Methods: A cross-sectional descriptive and analytical study was conducted between December 2024 and April 2025 among 514 healthcare professionals, including nurses, doctors, midwives, and technicians, working in public health facilities. Data were collected through a self-administered, expert-validated online questionnaire covering socio-professional characteristics and knowledge of leishmaniasis. Knowledge was scored on a 16-point scale and classified as "good" (9–16) or "poor" (0–8). Binary logistic regression was performed to identify predictors of good knowledge, with $p < 0.05$ as the threshold for statistical significance.

Results: Overall, 67.9% of participants demonstrated good knowledge of leishmaniasis. Health professionals from Essaouira were 13 times more likely to have good knowledge than those from Youssoufia ($p = 0.035$; Odds ratios [OR] = 13.5; 95% confidence interval [CI]: 1.20–152.21). Those holding a doctorate ($p = 0.050$; OR = 8.00; 95% CI: 0.998–64.11) and those with 11–15 years of experience ($p = 0.046$; OR = 10.12; 95% CI: 1.04–98.49) exhibited significantly higher awareness. Completing a university-level course on leishmaniasis strongly enhanced knowledge ($p = 0.002$; OR = 4.55; 95% CI: 1.76–11.81).

Conclusion: The study revealed uneven distribution of knowledge among healthcare professionals, with educational level, experience, and training as key determinants. Strengthening targeted training programs and integrating leishmaniasis content into academic curricula are essential for improving disease control. Future research should adopt a broader One Health perspective involving veterinary and environmental sectors to enhance surveillance, early detection, and community awareness.

Keywords: endemic regions, healthcare professionals, knowledge, Leishmaniasis, Morocco, One Health.

INTRODUCTION

Leishmaniases are parasitic diseases caused by flagellated protozoa of the *Leishmania* genus that infect both humans and animals. These infections pose serious public health challenges worldwide due to their broad epidemiological and clinical variability, diversity of reservoir hosts, and complex life cycles involving insect vectors and mammalian hosts [1]. Leishmaniasis is currently endemic in approximately 89 countries across Africa, Asia, parts of Central and South America, and the Mediterranean basin, making it a major global health concern [2, 3]. The World Health Organization (WHO) estimates that 12–15 million people worldwide are infected with leishmaniasis and ranks it among the seven most severe neglected tropical diseases (NTDs) [2, 3].

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In Morocco, leishmaniasis occurs mainly in two forms: Cutaneous leishmaniasis (CL), the most prevalent, and visceral leishmaniasis (VL), which is rarer but almost invariably fatal if left untreated [1]. In 2016, CL was recognized as a significant public health problem, with Morocco classified as an endemic country where nearly 14% of the population remains at risk [4]. The persistence of leishmaniasis in Morocco reflects the complexity of its transmission cycle, the multiplicity of host and parasite species, the limited availability and high cost of effective drugs, their potential toxicity, emerging resistance, and the continued absence of a human vaccine [5, 6].

Since the establishment of Morocco's National Leishmaniasis Control Program in 1997, epidemiological surveillance has intensified, yet sustained concern remains over disease expansion and underreporting [7]. Health professionals play a critical role in this context. Their knowledge is vital for early detection, accurate diagnosis, and effective community education on preventive measures, including vector-control and recognition of reservoir risks [7].

Studies assessing the knowledge, attitudes, and practices (KAP) of healthcare workers toward leishmaniasis reveal considerable regional and professional disparities. In countries such as Portugal and Pakistan, awareness levels are relatively high: Over 90% of Portuguese professionals identified the parasite and its vector as key transmission elements, while 97.5% of Pakistani respondents recognized *Leishmania* as a protozoan and understood its zoonotic nature [8, 9]. However, in many parts of South Asia and Africa, knowledge varies widely and is often shaped by training exposure, endemicity, and access to educational resources. Although targeted educational interventions have been shown to enhance knowledge, they remain inconsistently applied [8, 9]. Persistent barriers, including limited training opportunities, weak surveillance systems, and inadequate integration of One Health principles, continue to impede control efforts globally.

Across Africa, knowledge deficiencies among health professionals have repeatedly been linked to diagnostic delays and inadequate case management. For instance, during a recent CL outbreak in Ethiopia's Somali region, WHO-led capacity-building programs revealed substantial gaps in local healthcare workers' preparedness [10]. Moreover, over half of African countries lack comprehensive epidemiological data due to underdiagnosis and underreporting [11]. Community-based study by Tamiru *et al*. [12] in endemic areas, such as Northwest Ethiopia, similarly indicates low awareness among both healthcare personnel and the general population, leading to delayed diagnosis and limited treatment access, particularly in rural settings.

Given that leishmaniasis is a zoonotic vector-borne disease sustained by animal reservoirs, its control requires an integrated One Health approach that unites human medicine, veterinary science, and environmental management. This collaborative framework is essential for identifying transmission hotspots, understanding reservoir ecology, and implementing sustainable preventive strategies [13–15]. Strengthening intersectoral cooperation among medical, veterinary, and environmental actors could markedly improve surveillance and disease control in endemic regions such as Morocco.

The Marrakech–Safi region, Morocco's most affected zone, continues to report the country's highest incidence rates. In 2023 alone, 722 cases of CL and 6 cases of VL were documented, underscoring the urgency of targeted interventions and enhanced professional awareness in this endemic area [16].

Although Morocco has implemented a national leishmaniasis control program since 1997, the persistence of new and re-emerging foci highlights major deficiencies in awareness and early detection capacities among frontline health professionals. Previous studies conducted in central Morocco have primarily focused on community-level KAP rather than the professional healthcare sector. For instance, Mounia *et al*. [6] reported low public awareness of leishmaniasis and inadequate understanding of its transmission and reservoir hosts in central Morocco, emphasizing the need for sustained education campaigns. However, this study did not evaluate healthcare providers, whose competencies are essential for timely diagnosis and effective management. Similarly, El-Mouhdi *et al*. [7] assessed the experiences of peripheral health professionals in El Hajeb Province and found limited diagnostic capacity, limited familiarity with the disease's clinical forms, and insufficient knowledge of vector ecology. Nevertheless, their work was confined to a single province, used a small sample, and lacked multivariate analysis to explore determinants of knowledge disparities.

To date, no comprehensive, region-wide assessment has examined how educational level, professional category, or training exposure influence the knowledge of health professionals about leishmaniasis in Morocco's most endemic region, Marrakech–Safi. Furthermore, earlier studies did not contextualize knowledge gaps within a One Health framework, despite leishmaniasis being a zoonotic disease requiring collaboration across human, veterinary, and environmental health sectors. This gap underscores the urgent need for broader, analytically robust investigations that evaluate the determinants of professional awareness and guide evidence-based capacity-building strategies to enhance Morocco's leishmaniasis surveillance and control efforts.

This study aimed to assess the knowledge of healthcare professionals regarding leishmaniasis and to identify the factors associated with good awareness across the Marrakech–Safi region, Morocco's most endemic zone. Specifically, it sought to:

1. Evaluate the extent of understanding among different categories of health professionals (nurses, doctors, midwives, and technicians) concerning the etiology, transmission, reservoirs, and clinical manifestations of leishmaniasis;
2. Analyze the relationship between socio-demographic and professional characteristics (educational level, years of experience, training exposure, and place of work) and their knowledge levels;
3. Determine how academic and continuous training programs influence awareness and preparedness for diagnosis and control; and
4. Generate evidence to guide policymakers in strengthening the integration of leishmaniasis education within medical curricula and continuous professional development frameworks.

Ultimately, this research provides a scientific foundation for targeted educational interventions and advocates for the adoption of a One Health approach that fosters collaboration among medical, veterinary, and environmental sectors to enhance leishmaniasis control and prevention in Morocco.

MATERIALS AND METHODS

Ethical approval

Ethical approval was granted by the Regional Directorate of the Ministry of Health and Social Protection of the Marrakech–Safi region on February 21, 2023 (Reference No. 639/2023). The authorization confirmed compliance with the Declaration of Helsinki. Participation was entirely voluntary, and electronic informed consent was obtained before questionnaire access. Participants could withdraw at any stage before submission.

No personal identifiers (names, IP addresses, or email addresses) were collected. Data were anonymized, stored on a password-protected database, and accessible only to the research team. The study complied with Moroccan biomedical research and data protection regulations (Law No. 09–08) and aligned with the general data protection regulation principles.

The study was conducted under the supervision of the Laboratory of Water Sciences, Microbial Biotechnologies, and Natural Resources Sustainability, Unit of Microbial Biotechnologies, Agrosciences, and Environment, ensuring full adherence to ethical and institutional standards.

Study period and location

This cross-sectional, descriptive, and analytical study was conducted from December 2024 to April 2025 in the Marrakech–Safi region, located in central Morocco (approximately 31.7° N, 8.4° W). The region covers 41,404 km2, representing nearly 6% of the national territory. It includes one prefecture (Marrakech) and seven provinces: Chichaoua, El Haouz, El Kelâa des Sraghna, Rhamna, Essaouira, Safi, and Youssoufia [17]. Morocco is considered one of the most endemic countries for leishmaniasis in North Africa [18]. The Marrakech–Safi region contains several active CL foci, such as Youssoufia [19], Al Hanchan [20], Chichaoua [21], and Al Haouz [22], with additional reports of VL cases [23]. The region's semi-arid climate, characterized by hot, dry summers and mild, wet winters, influences the abundance and seasonal dynamics of sandfly vectors by affecting temperature, humidity, soil moisture, and vegetation cover. The main sandfly species identified in this region, *Phlebotomus papatasi*, *Phlebotomus sergenti*, and *Phlebotomus longicuspis*, are established vectors of CL and are well adapted to these environmental conditions [17, 24].

Study design

The study followed a cross-sectional, descriptive-analytical design, based on strengthening the reporting of observational studies in epidemiology guidelines. Data collection was conducted, as shown in Figure 1, which illustrates the participant recruitment and data flow process.

Study population and eligibility criteria

The target population comprised healthcare professionals, nurses, doctors, midwives, and health technicians, working in public health institutions across the Marrakech–Safi region.

Inclusion criteria

Practicing in the region during the study period, voluntary participation with informed consent, and completion of the online questionnaire.

Exclusion criteria

Refusal to participate or submission of incomplete questionnaires.

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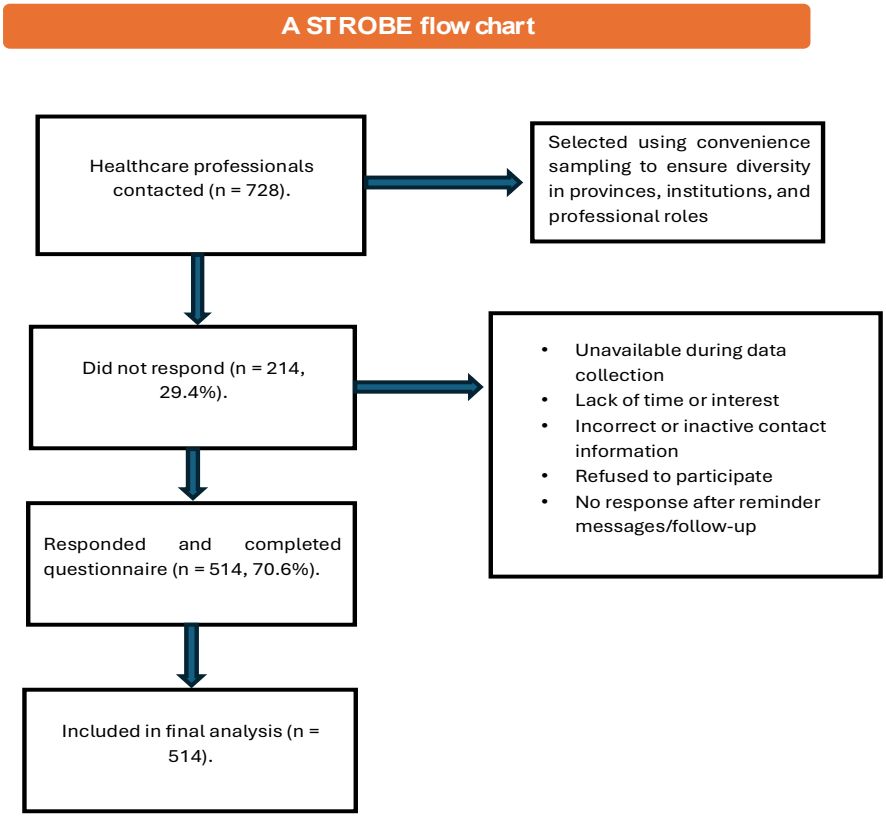

Figure 1: Flow diagram of participant recruitment and response according to the strengthening the reporting of observational studies in epidemiology guidelines.

Sampling strategy and sample size

Participants were recruited using convenience sampling, a nonprobability sampling method chosen for its feasibility and its ability to maximize participation. While this method facilitates access to respondents, it can introduce selection bias and limit the generalizability of findings. To mitigate this, participants were recruited from diverse provinces, health facilities, and professional roles.

The sample size was determined using the *Check Market by Medalia* online calculator [25], assuming a 95% confidence level, 5% margin of error, and an expected proportion of 50%. Based on a total target population of 6,720 healthcare professionals, the minimum required sample size was 364. To compensate for non-responses, 728 professionals were contacted, of whom 514 completed the questionnaire, yielding a response rate of 70.6%.

Questionnaire development and validation

The questionnaire, developed in French, was based on national leishmaniasis control guidelines and previously published studies. It comprised a combination of closed-ended, semi-structured, and open-ended questions, targeting two main domains:

1. Socio-professional characteristics, including academic qualifications and professional experience (formal education, ongoing training, workshops, and refresher courses);
2. Knowledge of leishmaniasis, covering clinical manifestations, transmission routes, vectors, and reservoirs.

Although designed to assess perceptions of vector and reservoir ecology, no entomological or veterinary data were collected, representing a methodological limitation.

The questionnaire underwent a three-stage validation process:

- Content validation: Reviewed by three health professionals (a doctor, nurse, and midwife) from endemic foci to ensure relevance and cultural adaptability.
- Linguistic review: Correction of grammatical and syntactic errors.
- Pilot testing: Administered to 30 professionals (10 doctors, 10 nurses, 5 technicians, and 5 midwives) to assess clarity and feasibility. The average completion time was 8–10 min, and minor refinements were made based on feedback. Each participant submitted a unique email to avoid duplicate entries. The survey was distributed online in French, the predominant professional language.

Data collection procedure

Data were collected through a self-administered online questionnaire using Google Forms. Access links were circulated through institutional email lists and official WhatsApp groups to maximize reach. Quality assurance procedures included:

- Restricting multiple submissions.
- Manual data cleaning for completeness and accuracy.
- Preserving voluntary participation and anonymity.

Knowledge scoring system

Knowledge of leishmaniasis was assessed using a 16-item structured questionnaire, with each correct answer awarded one point (total score: 0–16). Based on prior study by Mounia *et al*. [6] conducted in central Morocco, participants were classified as having:

- Good knowledge: 9–16 points
- Poor knowledge: 0–8 points.

This scoring system provided a standardized approach for comparing awareness levels across professional categories and provinces.

Data management and statistical analysis

Data were recorded in Microsoft Excel 2016 (Microsoft Corp., Washington, USA) and analyzed using JAMOVI software (version 2.3.28, https://www.jamovi.org/). Statistical significance was set at $p \leq 0.05$. Descriptive statistics summarized socio-professional variables and knowledge scores.

Before regression analysis, collinearity diagnostics confirmed that all predictors had acceptable variance inflation factors (1.08–1.72), indicating no multicollinearity. The relationship between knowledge and explanatory variables was examined using binomial logistic regression, appropriate for dichotomous outcomes (“good” vs. “poor” knowledge).

Odds ratios (ORs) with 95% confidence intervals (CIs) were computed to estimate the likelihood of good knowledge across categories. The logistic regression model demonstrated a significant fit ($\chi^2 = 250$, df = 33, $p < 0.001$), with moderate explanatory power (McFadden’s $R^2 = 0.389$; Cox and Snell $R^2 = 0.388$; Tjur $R^2 = 0.541$). The receiver operating characteristic curve (Figure 2) showed high sensitivity and specificity, confirming the model’s predictive reliability.

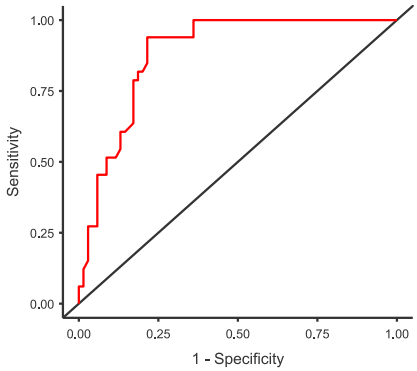

Figure 2: Receiver operating characteristic curve for the logistic regression model predicting knowledge levels.

RESULTS

Demographic and socio-professional characteristics of participants

A total of 514 out of 728 invited health professionals participated in the study, representing a response rate of 70.6%. Table 1 presents their demographic and professional distribution. The majority of respondents were female (66%), and most were within the 20–29 years age group (72.8%). Nearly 69.8% of participants had ≤5 years of professional experience, whereas only 2.9% had between 16 and 20 years of experience.

Professionally, nurses represented the largest group (66.0%), followed by health technicians (18.5%), doctors (11.7%), and midwives (3.9%). More than three-quarters (75.4%) of respondents worked in urban areas, with the Marrakech Province accounting for the highest representation (32.1%). In terms of workplace distribution, the largest proportion (32.1%) was employed in provincial hospitals, followed by health centers (28.2%), and local hospitals (16.3%).

These demographic findings reflect a predominantly young, urban-based, and nurse-led health workforce within the Marrakech–Safi region.

Table 1: Socio-professional characteristics of health professionals in this study.

Variables	Frequency	Percentage	95% CI
Gender			
Male	175	34.0	29.8–38.3
Female	339	66.0	61.7–70.2
Province			
Youssoufia	50	9.7	7.2–12.7
Al Haouz	15	2.9	1.7–5.0
Chichaoua	55	10.7	8.1–13.9
El Kelaa des Sraghna	10	1.9	1.0–3.6
Essaouira	50	9.7	7.2–12.7
Marrakech	165	32.1	28.1–36.4
Rhamna	20	3.9	2.4–6.3
Safi	149	29.0	25.1–33.2
Profession			
Nurse	339	66.0	61.7–70.2
Doctor	60	11.7	9.0–15.0
Midwife	20	3.9	2.4–6.3
Health technician	95	18.5	15.1–22.3
Level of study			
Bachelor’s degree	369	71.8	67.7–75.6
Doctorate	75	14.6	11.7–18.1
Master’s degree	70	13.6	10.8–17.0
Place of work			
Urban	388	75.5	71.5–79.0
Rural	126	24.5	21.0–28.5
Type of organization			
Local hospital	84	16.3	13.3–19.8
Health center	145	28.2	24.4–32.3
Provincial hospital	165	32.1	28.1–36.4
University hospital	80	15.6	12.7–19.1
Other	40	7.9	5.8–10.6
Seniority (years)			
6–10	85	16.5	13.4–20.1
11–15	50	9.7	7.2–12.7
16–20	15	2.9	1.7–5.0
More than 21	5	1.0	0.4–2.5
<5	359	69.8	65.7–73.7
Age (years)			
20–29	374	72.8	68.7–76.5
30–39	120	23.3	19.7–27.3
40–49	20	3.9	2.4–6.3
50–59	0	0	—

CI = Confidence interval

Local terminology and perception of leishmaniasis

Table 2 outlines the local names used for leishmaniasis in the study area. The most common vernacular term was “Hbouba” (27.6%), followed by “Chmania” (22.1%), “Chniwla” (16.6%), and “Izi” (12.3%). Less frequently cited names included “Chmaniose” (4.3%) and “Mou jlood” (3.1%). This lexical diversity illustrates regional variations in disease perception, highlighting cultural associations between the disease and its visible clinical manifestations.

Distribution of knowledge scores

The distribution of participants’ knowledge scores is illustrated in Figure 3. The median score was 10, indicating a moderate overall knowledge level. A wide interquartile range and the presence of outlier values reflected considerable variability across participants. The violin-shaped plot showed a concentration of scores

around the median, suggesting that most professionals had comparable, though uneven, awareness of leishmaniasis.

Table 2: Local names of leishmaniasis in the Marrakech–Safi region.

Local name	Frequency	Percentage	95% CI
Chmania	36	22.1	15.8–29.5
Chmaniose	7	4.3	2.1–8.6
Chniwla	27	16.6	11.4–23.6
Hbouba	45	27.6	21.0–35.4
Izi	20	12.3	8.1–18.3
Mard namoussa	10	6.1	3.3–10.9
Mou jloud	5	3.1	1.3–7.1
Nare farsia	13	8	4.7–13.3

CI = Confidence interval

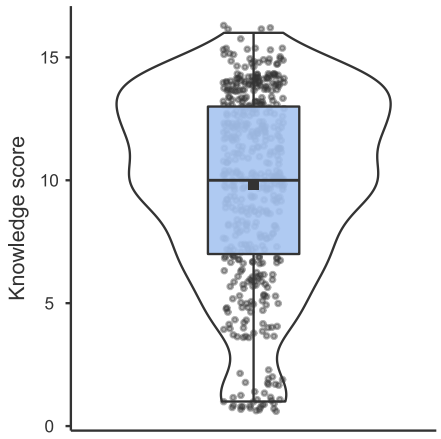

Figure 3: The boxplot illustrates the distribution of health professionals' knowledge scores on leishmaniasis.

Knowledge of causative agent, vectors, and reservoirs

As shown in Table 3, the majority of respondents (96.3%) correctly identified *Leishmania* as the causative agent, while 3.7% were unaware. Knowledge of the number of Leishmania species in Morocco was mixed: 35.2% cited two species, 29.8% cited three, and 33.1% were uncertain.

Regarding vectors, 63.8% correctly identified female sandflies as the primary vector, while others confused them with female *Anopheles* (15%) or fleas (1.9%). Over half (54.7%) knew that the vector is active at night, while 25.3% were unsure.

A strong majority (84.4%) correctly recognized insect bites as the mode of transmission, although small proportions incorrectly cited animal excrement (3.7%) or contaminated food (2.7%). With respect to reservoirs, 51.6% identified both humans and animals correctly, while others mentioned non-biological sources such as food, water, or soil. Notably, 65.4% of participants were unaware of the vector's developmental habitat, indicating a gap in entomological knowledge.

In terms of causative species, 58.0% correctly identified *Leishmania tropica*, *Leishmania infantum*, and *Leishmania major* as responsible for CL, whereas 40.7% recognized *L. infantum* as the causative agent of VL.

Knowledge of clinical manifestations, treatment, and prevention

Table 4 summarizes the participants' understanding of the disease's clinical forms and management. Most respondents (89.9%) identified leishmaniasis as a parasitic disease, while a minority classified it as bacterial (4.7%) or viral (1.8%).

Concerning clinical symptoms, 75.1% recognized fever, weight loss, and splenomegaly as signs of VL, while 81.1% identified skin lesions as the hallmark of CL.

Regarding treatment knowledge, 34.0% correctly cited meglumine antimoniate as the first-line therapy for CL, and 28.0% identified it as the primary VL treatment. Another 19.6% mentioned amphotericin B, whereas 38%–39% of participants were uncertain about recommended regimens.

Most respondents (85.4%) correctly stated that CL is more prevalent in rural areas, and 81.7% demonstrated awareness of protective measures against the sandfly vector. Despite this generally good awareness, the data

revealed important gaps in therapeutic and vector-related knowledge.

Table 3: Knowledge of health workers about reservoirs, modes of transmission, and vectors.

Variables	Effective	Percentage	95% CI
Causal agent of leishmaniasis			
I don't know	19	3.7	2.4–5.8
Leishmania	495	96.3	94.2–97.6
Number of Leishmaniasis Species in Morocco			
2	181	35.2	31.2–39.5
3	153	29.8	26.0–34.0
4	10	1.9	1.0–3.6
I don't know	170	33.1	29.1–37.3
Vector of leishmaniasis			
Insects (Fleas)	10	1.9	1.0–3.6
Insects (male Anopheles)	77	15.0	12.2–18.4
Insects (female sandflies)	328	63.8	59.6–67.8
I don't know	99	19.3	16.0–23.1
The leishmaniasis vector is active in			
I don't know	130	25.3	21.7–29.3
Day	28	5.4	3.7–7.9
Night	281	54.7	50.4–58.9
Anytime	75	14.6	11.7–18.0
Parasites responsible for leishmaniasis are generally transmitted to humans through			
I don't know	43	8.4	6.3–11.1
Contact with animal excrement	19	3.7	2.4–5.8
Ingestion of contaminated food	14	2.7	1.6–4.6
Inhalation	4	0.8	0.3–2.1
By an insect bite	434	84.4	81.0–87.3
Reservoirs of leishmaniasis include			
Food and man	20	3.9	2.5–6.0
Water and animals	94	18.3	15.2–22.0
Water and dirt	76	14.7	11.9–18.0
Man and animal	265	51.6	47.3–55.9
I don't know	59	11.5	9.0–14.7
The place of leishmaniasis vector development			
I don't know	336	65.4	61.2–69.3
Yes	178	34.6	30.7–38.8
The *Leishmania* species responsible for CL in Morocco are as follows			
L. amazonensis, *L. aethiopica*, and *L. braziliensis*	38	7.4	5.4–10.0
L. amazonensis, *L. infantum*, and *L. aethiopica*	10	1.9	1.0–3.6
L. tropica, *L. infantum*, and *Leishmania major*	298	58.0	53.7–62.2
I don't know	168	32.7	28.7–36.9
The *Leishmania* species responsible for VL in Morocco			
L. amazonensis	24	4.7	3.2–6.9
L. braziliensis	4	0.8	0.3–2.1
L. infantum	209	40.7	36.5–45.0
L. tropica	133	25.8	22.1–29.9
I don't know	144	28.0	24.2–32.2

CI = Confidence interval, CL = Cutaneous leishmaniasis, VL = Visceral leishmaniasis, *L. amazonensis = Leishmania amazonensis*, *L. aethiopica = Leishmania aethiopica*, *L. braziliensis = Leishmania braziliensis, L. tropica = Leishmania tropica*, *L. infantum = Leishmania infantum*

Training exposure and professional preparedness

As shown in Table 5, 55.4% of health workers had previously received training on leishmaniasis, while 44.6% had not. Among those trained, 43.9% had undergone academic training, 10.4% had received both academic and non-academic instruction, and only 1.0% participated in ongoing professional training. Nearly half (44.7%) reported no training at all, underscoring the urgent need for structured, continuous capacity-building initiatives to enhance professional competence in leishmaniasis detection and control.

Determinants of knowledge among health professionals

Table 6 presents the association between knowledge levels and socio-professional variables. Overall, 67.9%

of participants demonstrated good knowledge, while 32.1% exhibited limited understanding. Health professionals from Essaouira were 13 times more likely to have good knowledge than those from Youssoufia (p = 0.035; OR = 13.5; 95% CI: 1.197–152.21). Educational attainment also showed a significant influence: Participants with a doctorate were 8 times more likely to possess good knowledge than those with a bachelor's degree (p = 0.050; OR = 8.00; 95% CI: 0.998–64.11).

Table 4: Health professionals' knowledge of leishmaniasis, clinical manifestations, treatment, and protection methods.

Variable	Effective	Percentage	95% CI
Leishmaniasis is			
I don't know	19	3.7	2.4–5.8
Bacterial disease	24	4.7	3.2–6.9
Parasitic disease	462	89.9	87.0–92.2
Viral disease	9	1.8	0.9–3.4
Symptoms of VL in adults include			
Fever, weight loss, and enlarged spleen	386	75.1	71.2–78.7
I don't know	63	12.3	9.8–15.4
Skin lesion(s)	65	12.6	10.0–15.8
CL symptoms include			
Joint pain	5	1.0	0.4–2.4
Fever, extreme pallor, weight loss, and splenic-hepatic-ganglionic syndrome	44	8.6	6.4–11.4
I don't know	48	9.3	7.0–12.2
Skin lesion(s)	417	81.1	77.5–84.2
The first-line treatment for CL in Morocco			
Amphotericin B	72	14.0	11.2–17.3
Meglumine antimoniate	175	34.0	29.9–38.3
Chloroquine	28	5.5	3.8–8.0
I don't know	200	38.9	34.7–43.3
Rifampicin	39	7.6	5.6–10.3
The first-line treatment for VL in Morocco is as follows:			
Amphotericin B	101	19.6	16.3–23.4
Meglumine antimoniate	144	28.0	24.2–32.2
Rifampicin	39	7.6	5.6–10.3
Chloroquine	33	6.3	16.3–23.4
I don't know	197	38.3	24.2–32.2
Leishmaniasis is more prevalent in Morocco			
I don't know	55	10.7	8.2–13.8
Rural	439	85.4	82.1–88.2
Urban	20	3.9	2.5–6.0
Methods of protection against leishmaniasis vector			
Yes	439	81.7	78.1–84.8
I don't know	55	18.3	15.2–21.9

CI = Confidence interval, CL = Cutaneous leishmaniasis, VL = Visceral leishmaniasis

Table 5: Training of health workers regarding leishmaniasis in the Marrakech–Safi region.

Variables	Frequency	Percentage	95% CI
Benefited from training on leishmaniasis			
No	229	44.6	40.2–49.1
Yes	285	55.4	50.9–59.8
Type of leishmaniasis course benefited			
No	229	44.7	40.3–49.2
Both	53	10.4	7.8–13.4
Ongoing training	5	1.0	0.3–2.3
Academic training	225	43.9	39.5–48.4

CI = Confidence interval

Similarly, professionals with 11–15 years of experience had tenfold higher odds of demonstrating good knowledge compared with those with 6–10 years of experience (p = 0.046; OR = 10.125; 95% CI: 1.041–98.49). Training exposure was another strong predictor: Individuals who had completed a course on leishmaniasis were 4 times more likely to have good knowledge (p = 0.001; OR = 4.18; 95% CI: 1.753–9.98), particularly those who attended academic courses (p = 0.002; OR = 4.55; 95% CI: 1.755–11.81).

No significant associations were found between knowledge level and gender, age, workplace type, or professional category. These findings underscore the importance of formal education, professional experience, and targeted academic training in improving disease-related knowledge among health professionals.

Table 6: Association of good knowledge of leishmaniasis with socio-professional factors.

Variables	Frequency	Percentage	p-value	OR	95% CI	
					Lower	Upper
Gender						
Male	125	24.3	Ref	Ref	Ref	Ref
Female	224	43.6	0.810	0.899	0.378	2.14
Province						
Youssoufia	20	3.9	Ref	Ref	Ref	Ref
Al Haouz	15	2.9	0.994	6.38e+7	0.000	Inf
Chichaoua	40	7.8	0.138	4.000	0.639	25.02
El Kelâa des Sraghna	10	1.9	0.995	6.38e+7	0.000	Inf
Essaouira	45	8.8	0.035*	13.500	1.197	152.21
Marrakech	115	22.4	0.098	3.450	0.796	14.96
Rhamna	15	2.9	0.427	3.000	0.199	45.24
Safi	89	17.3	0.257	2.308	0.544	9.79
Profession						
Nurse	234	45.5	REF	REF	REF	REF
Doctor	55	10.7	0.139	4.915	0.5954	40.57
Midwife	10	1.9	0.436	0.447	0.0589	3.39
Health technician	50	9.7	0.120	0.447	0.1617	1.23
Level of study						
Bachelor's degree	234	45.5	Ref	Ref	Ref	Ref
Doctorate	70	13.6	0.050*	8.00	0.998	64.11
Master's degree	45	8.8	0.963	1.03	0.314	3.37
Place of work						
Urban	239	47.0	Ref	Ref	Ref	Ref
Rural	105	20.6	0.053	3.15	0.986	10.06
Type of organization						
Local hospital (HP)	54	10.5	Ref	Ref	Ref	Ref
Addictology center	5	1.0	0.997	2.29e+7	0.000	Inf
Health center (CS)	110	21.4	0.410	1.692	0.484	5.92
Hemodialysis center	5	1.0	0.997	2.29e+7	0.000	Inf
Provincial hospital (CHP)	100	19.5	0.749	0.828	0.261	2.63
University hospital	45	8.8	0.593	0.692	0.180	2.67
Rural dispensary	10	2.0	0.997	2.29e+7	0.000	Inf
Higher Institute of nursing professions and health techniques	5	1.0	0.997	2.29e+7	0.000	Inf
Public health laboratory	5	1.0	0.997	2.29e+7	0.000	Inf
Support structure	10	1.9	0.995	2.29e+7	0.000	Inf
Seniority (years)						
6–10	40	7.8	Ref	Ref	Ref	Ref
11–15	45	8.8	0.046*	10.125	1.041	98.49
16–20	15	2.9	0.992	4.79e+7	0.000	Inf
More than 21	5	1.0	0.996	4.79e+7	0.000	Inf
Up to 5	244	47.5	0.128	2.297	0.788	6.70
Benefited from training on leishmaniasis						
No	119	23.2	Ref	Ref	Ref	Ref
Yes	230	44.7	0.001*	4.18	1.753	9.98
Type of leishmaniasis course benefited						
No	119	23.2	Ref	Ref	Ref	Ref
Both	40	7.8	0.058	4.79	0.946	24.27
Ongoing course	0	0.0	0.991	1.66e-7	0.000	Inf
Academic course	190	37.0	0.002*	4.55	1.755	11.81
Age (years)						
20–29	254	49.4	Ref	Ref	Ref	Ref
30–39	75	14.6	0.678	0.817	0.314	2.12
40–49	20	3.9	0.993	2.09e+7	0.000	Inf
50–59	0	0	0.995	2.09e+7	0.000	Inf

Ref = Reference value in analysis, CI = Confidence interval, OR = Odds ratio, * = Significant value, e = Exponential, Inf = Infinity

DISCUSSION

Overview and significance of the study

This study represents the first large-scale quantitative assessment of health professionals' knowledge regarding leishmaniasis in the Marrakech–Safi region, Morocco's most endemic zone. By linking educational background, professional experience, and qualifications with knowledge levels, the study offers new insight into institutional disparities and geographic variations that influence disease awareness. The identification of provincial differences, particularly between Essaouira and Youssoufia, adds a novel micro-geographical dimension that has seldom been explored in Moroccan research.

Leishmaniasis, recognized as one of the most NTDs globally, continues to pose a significant public health challenge in Morocco, where a national control program has been in place since 1997 [26]. Despite these efforts, disease persistence in endemic foci suggests gaps in early detection, knowledge, and surveillance among health workers.

Composition and role of the health workforce

Among the 514 health professionals who participated, nurses constituted the majority (66%), followed by health technicians (18.5%) and physicians (11%). This distribution mirrors Morocco's healthcare structure, in which nurses serve as the operational backbone of public health programs [27]. Nurses play a pivotal but often under-recognized role in disease surveillance, patient education, and community-based interventions [28]. Their proximity to rural populations enables them to act as first-line responders for leishmaniasis detection and prevention. As highlighted in another NTD study by Blood-Siegfried *et al*. [29], empowering nurses through targeted training enhances overall control outcomes.

Local terminology and cultural perceptions

The study identified diverse local names for leishmaniasis across the region, such as "Mard namossa," "Izi," and "Chniwla," particularly common in Youssoufia and El Hajeb [6, 30]. Other terms like "Hbouba" were associated with visible skin lesions, reflecting the community's perception of the disease based on its clinical manifestations. These findings underline the sociocultural dimension of disease recognition, where naming reflects lived experience but often remains detached from biomedical understanding and reporting systems. Integrating such local knowledge into One Health awareness programs could facilitate earlier diagnosis and community engagement.

Knowledge of etiology, species diversity, and vectors

A substantial proportion (89.9%) of respondents correctly identified leishmaniasis as a parasitic disease, consistent with findings from other endemic settings [7, 18, 31, 32]. However, only 29.8% were aware that three Leishmania species circulate in Morocco. More than half correctly identified *L. tropica*, *L. infantum*, and *L. major* as agents of CL, while 40.7% recognized *L. infantum* as responsible for VL. Transmission knowledge was generally strong: 84.4% knew that the disease is transmitted through insect bites, and 63.8% correctly named female sandflies as the vector. Nevertheless, 15% mistakenly identified female Anopheles, reflecting a lingering association with malaria control campaigns that dominated Morocco's public health focus until its elimination in 2012 [33]. Notably, 65.4% of respondents did not know where sandflies develop, corroborating previous findings from El Hajeb Province [34], which highlighted limited entomological understanding among healthcare workers. Such knowledge gaps emphasize the need for vector ecology education within medical and paramedical curricula to improve integrated surveillance.

Awareness of clinical manifestations and treatment

Clinically, 75.1% of professionals recognized the classic symptoms of VL, fever, pallor, weight loss, and hepatosplenomegaly, while 81.1% correctly associated CL with skin ulcerations [35]. These rates are encouraging but indicate that nearly one-fifth of participants remain uncertain about clinical features.

Regarding treatment, only 34.0% and 28.0% correctly identified meglumine antimoniate as the first-line therapy for CL and VL, respectively. This is concerning given that meglumine antimoniate remains the national standard treatment [35]. The relatively low recognition rate suggests the need for refresher training on current therapeutic guidelines. This knowledge disparity is particularly relevant because CL is more widespread than VL in Morocco, possibly explaining greater familiarity with cutaneous forms but limited awareness of systemic disease management.

Provincial disparities and local epidemiological influence

The study revealed notable spatial disparities in knowledge across provinces. Health professionals in

Essaouira were significantly more likely to demonstrate good knowledge than those in Youssoufia (OR = 13.5; 95% CI: 1.197–152.21). This can be attributed to higher disease prevalence and longstanding exposure in Essaouira, where recurrent outbreaks have fostered practical experience and focused training programs [36]. Conversely, Youssoufia, recognized as a newly emerging focus in 2023 [19], has limited historical exposure, underscoring the importance of adaptive training programs in new or reactivated endemic zones. This approach would enhance local capacity and sustain early surveillance in emerging areas.

Influence of education, experience, and training

Educational attainment and experience emerged as strong predictors of knowledge. Participants with doctorate degrees were 8 times more likely to exhibit good knowledge than those with bachelor's degrees. Doctoral programs emphasize critical thinking, research methodology, and continuous professional engagement, enabling a deeper understanding of complex diseases such as leishmaniasis. Access to scientific conferences, academic networks, and research collaborations may further enhance their knowledge base.

Similarly, professionals with 11–15 years of experience demonstrated significantly higher awareness than those with 6–10 years. Senior practitioners often gain cumulative experience from managing diverse clinical cases, participating in workshops, and mentoring junior staff. A prior study in El Hajeb Province [34] found that greater seniority is associated with improved vector-related knowledge. Experienced professionals are also more likely to be involved in policy formulation and local disease control programs, reinforcing their expertise.

Training exposure also played a decisive role. Those who had taken academic courses on leishmaniasis were 4 times more likely to have good knowledge than those without training. Structured education programs provide comprehensive coverage of epidemiology, diagnosis, treatment, and prevention, fostering long-term retention and clinical competence. This aligns with evidence that continuous professional education significantly enhances knowledge and practices related to parasitic and zoonotic diseases [37]. Similar recommendations have been made for Essaouira, where sustained training and vector-control initiatives have yielded measurable benefits [36].

Implications for One Health and public health integration

While this study focused primarily on human healthcare workers, the findings underscore the need to extend similar knowledge assessments to veterinary and environmental health professionals. Since leishmaniasis involves animal reservoirs and vector ecology, an integrated One Health approach is indispensable for understanding and interrupting transmission cycles. Collaborative frameworks that unite medical, veterinary, and environmental sectors can facilitate early detection, vector monitoring, and reservoir surveillance, aligning with Morocco's national One Health strategy for zoonotic diseases. Strengthening such cross-sectoral collaboration will enhance the sustainability of leishmaniasis control and prevention in endemic regions.

Study limitations

Several limitations should be acknowledged. The use of convenience sampling may have introduced selection bias, affecting representativeness. The online self-administered survey could lead to response bias, as participants might have consulted external sources or discussed responses. In addition, individuals with limited internet access or digital literacy may have been inadvertently excluded. The study also focused solely on public health professionals, excluding private-sector and veterinary practitioners, which may restrict generalizability within a broader One Health context. Despite these constraints, the findings remain robust and provide valuable baseline data for future comparative studies and targeted interventions aimed at strengthening professional competence in endemic settings.

Concluding perspective

By explicitly adopting a One Health perspective, this study highlights that strengthening the knowledge base of healthcare professionals is fundamental to improving vector-control, animal reservoir surveillance, and early case detection. Integrating leishmaniasis-specific training within academic curricula and continuing education frameworks will enhance professional preparedness and contribute to sustainable disease control. These findings support Morocco's national strategy against leishmaniasis and offer a replicable framework for integrated leishmaniasis control across North Africa and other endemic regions.

CONCLUSION

This study provides the first large-scale, region-wide assessment of health professionals' knowledge of leishmaniasis in Morocco's most endemic region, the Marrakech–Safi region. Among the 514 respondents, 67.9% demonstrated good knowledge, while 32.1% showed limited awareness. Knowledge was significantly associated

with province, educational attainment, professional experience, and academic training. Health professionals from Essaouira were 13 times more likely to have good knowledge than those from Youssoufia, reflecting the influence of local endemicity and exposure. Similarly, participants with doctoral degrees and those with 11–15 years of experience exhibited markedly higher knowledge levels. Completing academic or continuing courses on leishmaniasis further enhanced understanding, underscoring the effectiveness of structured training in strengthening professional preparedness.

Practical implications of these findings emphasize the urgent need to integrate leishmaniasis education into medical and nursing curricula, expand continuing professional development programs, and reinforce vector- and reservoir-focused training at the provincial level. Given that nurses and health technicians form the majority of Morocco's healthcare workforce, empowering them with updated diagnostic and preventive skills is crucial for early case detection, patient education, and effective disease control.

A major strength of this study lies in its large, regionally representative sample and analytical design, which identified the determinants of knowledge disparities and provided a robust statistical model (McFadden's R^2 = 0.389). However, limitations include potential selection bias due to convenience sampling, response bias inherent in self-administered online surveys, and limited inclusion of private and veterinary sectors, which restricts broader One Health extrapolation.

Future research should adopt a multidisciplinary One Health framework encompassing human, veterinary, and environmental health professionals to assess knowledge and practices comprehensively. Expanding such studies to other Moroccan regions and longitudinally evaluating training outcomes would provide valuable evidence for national policy.

Enhancing professional knowledge through targeted, continuous, and intersectoral training remains central to Morocco's leishmaniasis control strategy. Strengthening collaboration between medical, veterinary, and environmental sectors will ensure early detection, improved case management, and sustainable reduction of leishmaniasis transmission in endemic zones.

DATA AVAILABILITY

The supplementary data can be made available from the corresponding author upon request.

AUTHORS' CONTRIBUTIONS

MYT, ME, MH, and LEF: Study design and conceptualization, data analysis, and visualization. MYT: Data collection, data entry, and drafted the manuscript. ME, MH, and LEF: Supervised the study and reviewed the manuscript. ME and LEF: Administrative work on the project. All authors have read and approved the final version of the manuscript.

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COMPETING INTERESTS

The authors declare that they have no competing interests.

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