Original Research Article

Epidemiology of *Mansonella perstans* and *Loa loa*: Prevalence and Specific Risk Factors in Njombe-Penja Health District, Littoral Region of Cameroon

ABSTRACT

Aim: This epidemiological survey aimed to determine the prevalence and specific risk factors of *Mansonella perstans* and *Loa loa* infections in the Njombe-Penja Health District of Cameroon. This region is endemic for filarial infections, posing significant public health burden.

Study design:A cross-sectional study was conducted among 360 participants, representing various occupational groups and areas of settlements.

Place and Duration of Study: The study was conducted in the Njombe-Penja Health Districtof the Littoral Region of Cameroon.Recruitment of participants, biological samples collection and questionnaire administration was done over a period of 1 month (July 2023).

Methodology: Fifty microliters (50µL) of peripheral blood was collected using capillary tubes, and analyzed for microfilarial presence and load. Structured questionnaires were used to collect data on demographic characteristics, exposure to risk factors, and preventive practices. Descriptive statistics, Chi-square tests with p-values, and odds ratios were calculated to identify significant associations.

Results: The results showed a prevalence of 45.8% for *M. perstans* and 19.4% for *L. loa*, with higher infection rates among farmers, especially those working in the large scale banana farming sector, and those living near water bodies (P =.002, OR = 3.15). Poor environmental sanitation (P =.004, OR = 2.75), and low monthly income (< 50,000 CFA) (P =.001, OR = 2.32), were also significantly associated with increased infection risk. Although 70.0% of participants were aware of the diseases, only 50.0% could identify key symptoms. Preventive measures like using bed nets and insect repellents were linked to a lower risk of infection (P =.003, OR = 2.10).

Conclusion:*Mansonella perstans* and *L. loa* infections are highly prevalent in the district, driven by occupational exposure, socioeconomic factors, and environmental risks.Interventions should focus on improving sanitation, enhancing public health education, and expanding healthcare access.

Keywords: Mansonella perstans; Loa loa; Filaria; Epidemiology; Risk Factor

1. INTRODUCTION

Filarial infections represent a significant public health challenge in tropical and subtropical regions, particularly in sub-Saharan Africa [1]. Among these infections, *M. perstans* and *L. loa* are noteworthy due to their prevalence and associated morbidity [1, 2]. *Mansonella perstans* is primarily transmitted by biting midges (*Culicoides* spp.), and is often overlooked in public health discussions, despite its widespread distribution and potential for causing non-specific symptoms [3]. Globally, studies have indicated that its prevalence varies significantly, with estimates ranging from 5% to 20% in some communities [4]. However, due to its often asymptomatic nature, many cases go unreported, contributing to its status as a neglected tropical disease [5, 6]. In Africa, *M. perstans* is widely distributed across West, Central, and East Africa, with countries such as Uganda, Nigeria, Ghana, Cameroon and Tanzania with significant prevalence [7]. In West and Central Africa, the prevalence of *M. perstans* can reach up to 70% in certain rural populations [8]. This infection tends to be more common in areas where people live close to water bodies, as the biting midges (*Culicoides* spp.) breed in moist environments. In Cameroon, studies in rural regions such as the South West, Littoral, and Center regions have shown prevalence rates ranging from 10% to 70% in various communities [4, 9, 10].

In endemic regions, chronic infection with *M. perstans* can lead to persistent symptoms such as fever, headache, and fatigue, which are frequently misattributed to other illnesses [11]. Additionally, infected individuals may experience angioedema, pruritus, and joint pains, with studies showing that these symptoms are exacerbated by immune responses to the microfilariae [6]. More severe morbidities include ocular complications, particularly retinal lesions, which can impair vision [12]. Research has also suggested a possible link between *M. perstans* and other parasitic infections, as co-infections may alter the clinical presentation and exacerbate immune system stress [13].

The presence of *M. perstans* is strongly associated with proximity to forests and agricultural zones, where the vectors thrive, hence, specific environmental, socioeconomic, behavioural and demographic factors account for the high prevalence of these parasites. *Culicoides* midges, which serve as vectors for *M. perstans*, breed in moist environments such as riverbanks, marshes, and floodplains. Populations living near water bodies are more likely to be exposed to the biting midges, increasing their risk of infection [6]. In these areas, vector control measures are often limited, and populations are exposed to a higher density of *Culicoides* bites, leading to higher infection rates [8]. In addition, individuals involved in agricultural work, particularly those who spend extended periods outdoors near vector breeding sites are at a higher risk of infection. Farming, fishing, and forestry activities increase exposure to the vectors, especially during peak biting periods [14]. Equally, poor housing infrastructure and lack of protective measures such as insecticide-treated nets (ITNs) contribute to increased vulnerability to midge bites [15]. Studies have shown that *M. perstans* infection is more prevalent among adults, particularly males, who are more likely to engage in outdoor activities. However, in some regions, infections occur across all age groups, with children and elderly people also being affected [6]. Individuals with weaker immune responses, including those who are malnourished or suffer from other infections, may be more susceptible to *M. perstans* infection [6].

On the other hand, *L. loa*, the causative agent of loiasis (commonly known as African eye worm), is transmitted by the bite of the *Chrysop* fly. The prevalence of *L. loa* is highly correlated with the distribution of its vector, which thrives in forested and agricultural areas. In medium and high transmission regions of Central and West Africa, where over 20 million individuals are chronically infected, loiasis largely affects rural populations living in forest and surrounding savannah regions [16]. *Loa loa* is found primarily in the tropical rainforest regions of West and Central Africa, with the highest prevalence in countries like Cameroon, Gabon, Equatorial Guinea, Congo, and Nigeria [1, 17, 18]. The prevalence of loiasis in some regions of Cameroon and Nigeria can be as high as 40% among rural populations. In the southern forested regions, particularly in areas such as the Central, East, and South Regions of Cameroon, prevalence can reach up to 30-40% in some communities [17, 19]. Loiasis is a major public health issue in Cameroon, not only because of its clinical effects but also due to its interference with Mass Drug Administration (MDA) programs targeting other filarial diseases. The high density of *L. loa* microfilariae in the blood of infected individuals increases the risk of serious complications during treatment with ivermectin [1, 20].

One of the hallmark symptoms of *L. loa* infection is the Calabar swelling, a localized, non-pitting edema that occurs as a reaction to the migrating adult worms [17]. Patients often report pruritus, pain, and fatigue, particularly when the worms migrate through subcutaneous tissues [21]. Ocular manifestations are another distinctive feature of *L. loa* infections, with adult worms occasionally migrating across the subconjunctiva, causing pain, irritation, and vision disturbances [22]. Although these ocular symptoms are typically self-limiting, the migration of worms can be alarming to patients. In rare cases, *L. loa* infections have been linked to more severe complications such as endomyocardial fibrosis, encephalopathy, and renal damage, particularly when microfilariae loads are high [23].

The risk factors for loiasis primarily relate to the ecology of the vector and human behavior. The dense forest canopy provides an ideal breeding ground for *Chrysop* flies, which thrive in shaded environments with high humidity [17]. The prevalence of loiasis varies with seasons, with higher transmission rates occurring during the rainy season when *Chrysop* flies are most active. Seasonal patterns of rainfall therefore contribute to the breeding cycles of the vectors, making certain times of the year more dangerous for acquiring infections [24].

The Njombe-Penja Health District, located in the Littoral Region of Cameroon, provides a unique ecological setting for the transmission of these filarial parasites. The region is characterized by its diverse geography, including rivers, swamps, and humid forests, which are conducive to the breeding of vectors responsible for the transmission of *M. perstans* and *L. loa* [25]. Despite this biological and ecological suitability of this Health District to *M. perstans* and *L. loa*, only one study, has so far reported on the endemicity of this area, with no concrete information on the unique risk factors that promote the survival of these pathogens [26]. Considering the fact that diverse farming activities are carried out in this area, with both ~~large and small scale~~large- and small-scale farming ongoing, the risk of high endemicity is very likely. Therefore, understanding the prevalence of these infections and their associated risk factors in this specific context is critical for effective public health interventions aimed at reducing their burden. This study sought to (1) determine the prevalence of *M. perstans* and *L. loa* infections among the population in Njombe-Penja Health District, (2) identify the demographic factors associated with *M. perstans* and *L. loa* infections, (3) assess environmental factors contributing to the transmission of *M. perstans* and *L. loa* in Njombe-Penja, and (4) examine the role of behavioral factors in the risk of *M. perstans* and *L. loa* transmission.

2. MATERIALS AND METHODS

2.1 Study Site

The study was conducted in the Njombe-Penja Health District, located in the Moungo Division of the Littoral Region of Cameroon. Geographically, Njombe-Penja is located between Latitudes 4^{o}34'and 4^{o}43' North of the equator, and Longitudes 9^{o}35' and 9^{o}54' East of the Greenwich meridian. It is characterized by a tropical rainforest climate, with heavy rainfall and high humidity throughout much of the year, particularly during the rainy season. This environment promotes dense vegetation and forested areas, which serve as ideal habitats for various vector species responsible for transmitting parasitic diseases, including *M. perstans* and *L. loa* [27]. The district includes a combination of lowland plains and areas of slightly elevated terrain, crisscrossed by rivers and streams that enhance the moisture levels and further support the breeding of vectors such as deer flies and biting midges, responsible for transmitting filarial infections [18]. The rivers and swamps scattered across the district make it a highly suitable area for agriculture, particularly banana, rubber, and oil palm plantations, which are major economic activities in the region. These agricultural practices, however, contribute to increased human-vector contact, raising the risk of vector-borne diseases. The population densityof 31, 792 people is moderate, with small communities and villages scattered across the district, mostly in proximity to the plantations. The road infrastructure is generally underdeveloped, particularly in the more remote areas, which can hinder access to healthcare services, thereby affecting disease management and control [6].

2.2 Study Population

The study targeted individuals of all age groups residing in the Njombe-Penja Health District, with a focus on those who are at higher risk due to factors such as occupation (peasant farmers, forestry workers, banana plantation workers), and proximity to vector breeding sites. The Njombe-Penja Health District is made up of a predominantly rural population engaged in agriculture, with banana, pawpaw, orange, pineapple, white pepper (*Piper nigrum*) and rubber being central to the local economy. This agricultural lifestyle places the population at heightened risk for filarial infections due to several environmental and socio-economic factors. Many residents live near forested or vegetative zones, which serve as breeding grounds for vectors like *Chrysop* flies (responsible for transmitting *L. loa*), and biting midges (*Culicoides* spp.), vectors of *M. perstans*. Most of the population works in agriculture, with long hours spent outdoors. This increases their exposure to vector bites, particularly during peak activity times for vectors. Workers in banana plantations and rubber farms are especially vulnerable, as these areas are often close to water sources, and the cultivation environment supports vector breeding[6]. The district's population of 31, 792 people is largely composed of low-income households that often lack adequate housing and access to healthcare. Public health education on vector-borne diseases is often limited in rural settings, leading to low awareness of the preventive measures that could reduce infection risk. The combination of low health literacy and poor infrastructure for vector control, such as insecticide-treated nets, makes the population particularly vulnerable to filarial infections.

2.3 Study Design

A cross-sectional survey was used to determine the prevalence of *M. perstans* and *L. loa* infections and assess associated risk factors. This design was appropriate for obtaining a snapshot of the infection status in the population at a specific point in time. Recruitment of participants, biological samples collection and questionnaire administration was done over a period of 1 month (July 2023).

2.4 Sample Size Determination

The sample size was calculated using Cochran's formula for an infinite population:

$n_0 = \frac{Z^2 \cdot p \cdot (1-p)}{e^2}$, and adjusted to a finite population using $n = \frac{n_0}{1 + \frac{n_0 - 1}{N}}$

Where:

n_0 = initial sample size (for an infinite population)

Z = Z-value (standard normal deviation corresponding to the desired confidence level, commonly 1.96 for 95% confidence)

p= estimated prevalence of the characteristic (in this case, 38.63% or 0.3863) according to Hzounda et al. [26] in 2024

e= desired margin of error (typically 5% or 0.05)

N = population size (in this case, 31,792)

Using Cochran's correction for finite populations and inserting the values above, the final sample size for the given population of 31,792 people with a prevalence of 38.63% and a margin of error of 5% was approximately 359.

2.5 Sampling Procedure

A multistage sampling technique was employed in which the Njombe-Penja Health District was first divided into clusters based on health areas. Communities were then identified and from these communities, participants were randomly selected for the study.

2.6 Data Collection Methods

A structured questionnaire was used to collect data on socio-demographic characteristics (age, gender, occupation), environmental factors (proximity to water bodies, housing conditions), and behavioral factors (use of insect repellents, time spent outdoors). Thick blood smears were collected from all participants using standard procedures. Fifty microliters(50µL) of blood was obtained via finger prick, using sterilized capillary tubes. The samples were then placed on glass slides. Blood samples were taken during the day as *L. loa* microfilariae exhibit diurnal periodicity,while *M. perstans* is non-periodic. For each sample collected, a thick blood film was prepared, air-dried and later stored in slide racks for subsequent analysis.

Comment [EE1]: Expressing the diurnal periodicity of Loa loa - authors should specify which period of the day they collected the samples ?

2.7 Laboratory Analysis

Thick blood films were prepared from the collected blood samples, stained with Giemsa stain, and examined under a microscope to identify and quantify the presence of *M. perstans* and *L. loa* microfilariae. Microfilaria identification was done following the World Health Organization's 1997 bench aid for diagnosis of filarial infections. The entire smear was examined and all microfilariae (mf) counted and registered, each slide being examined blindly by two independent laboratory technicians with good skills on filarial identification, and discrepancies resolved by a senior technician. The parasite load in mf/50 µl of blood was quantified using the expression mf/Ml (microfilariae per milliliter)= mf counted x1000µl/50 µl. For individuals testing positive, the microfilarial (mf) load was classified according to standard categories (low, moderate, and high).

2.8 Data Analysis

Descriptive statistics using Statistical Software for Social Sciences (SPSS Version 20.0) to show the prevalence of *M. perstans* and *L. loa* infections were performed. Demographic and environmental characteristics of the participants were summarized using frequency counts and percentages. Chi-square tests were used to examine the association between categorical variables and infection status. Logistic regression analysiswere employed to identify risk factors associated with the infections. Multivariate models were used to adjust for potential confounding factors, and odds ratios (OR) with 95% confidence intervals (CI) to quantify the strength of associations.

2.9 Ethical Considerations

Ethical approval was obtained from theMinistry of Public Health (see Appendix). Administrative clearance was obtained from the Health District. Participation in the study was voluntary as participants provided their informed consent after being fully informed about the purpose, methods, risks, and benefits of the study, explained to them in French, English and Pidgin English. As the study involved blood samples for diagnostic purposes, we ensured that risks such as pain from needle pricks or infection were minimized through the use of sterile equipment and trained personnel. Personal data, including medical history and results of diagnostic tests, were kept confidential using proper data protection protocols. To minimize bias, we ensured that the selection of study participants was fair and equitable, avoiding targeting vulnerable populations. Therefore, all eligible individuals, regardless of gender, age, or socioeconomic status, had equal opportunity to participate in the study. Those who were detected microfilaria (mf) positive were referred to the Njombe-Penja District Hospital for appropriate treatment.

3. RESULTS

3.1 Socio-demographic Characteristics of Study Participants

In terms of age, the majority of participants (35%) of the sample populationwere aged21-35 years, followed by those aged 36-55 years (30%), and younger participants aged 5-20 years (20%) (Table 1). The oldest age group, 56 years and above, constituted the smallest proportion, representing only 15% of the population. Gender-wise, the findings showed a slight female majority in the sample, with them representing 55%, and males 45%. Education levels varied, with 40% of the participants having completed secondary education, indicating moderate literacy levels. There were many participants with primary education (30%), while 15% of participants had no formal education and another 15% had tertiary education. Occupationally, farmers and students each made up 25% of the sample, reflecting the rural or agricultural nature of the district, as well as a significant presence of young, school-going participants. Traders (20%) and civil servants (15%) represented a smaller proportion of the sample, with another 15% being unemployed. Urban residents formed the largest group (40%), while semi-urban and rural residents were equally represented at 30% each (Table 1).

Table 1. Socio-demographic characteristics of study participants

Demographic Variable	Category	Frequency Count (n=360)	Percentage (%)
Age	05 – 20	72	20
	21 – 35	126	35
	36 – 55	108	30
	56 years and above	54	15
Gender	Male	162	45
	Female	198	55
Level of Education	No formal education	54	15
	Primary	108	30
	Secondary	144	40
	Tertiary	54	15
Occupation	Farmer	90	25
	Trader	72	20
	Civil Servant	54	15
	Unemployed	54	15
	Student	90	25
Place of Residence	Urban	144	40
	Semi Urban	108	30
	Rural	108	30

3.2 Prevalence and Filarial Loads of *Mansonella perstans* and *Loa loa*Among Study Participants

For *M. perstans* infection among males, the prevalence was 47.2%, with the remaining 52.8% not infected (Table 2). The filarial load distribution shows that; 47.1% of infected males had a load between 100-500 mf/mL, 29.4% had a load of 501-1000 mf/mL, and 23.5% had loads above 1000 mf/mL.Among females, the prevalence was 44.4%, slightly lower than males, with 55.6% not infected. For the infected females, 37.5%, 37.5%, and 25.0% had a load of 100-500 mf/mL, 501-1000 mf/mL and above 1000 mf/mL, respectively. The overall prevalence of *M. perstans* among the total sample was 45.8%, with 54.2% uninfected. The filarial load distribution for the total population showed 42.4% with 100-500 mf/mL, 33.3% with 501-1000 mf/mL, and 24.2% with loads above 1000 mf/mL.

For *L. loa* infection, among males, the prevalence was 24.7%. The filarial load distribution for infected males showed that 38.5%,30.8%, and 30.8% had a load of 100-500 mf/mL, 501-1000 mf/mL, andabove 1000 mf/mL, respectively.Among females, the prevalence was 15.2% (Table 2). The filarial load distribution for infected females was; 45.5%,27.3% and 27.3%, having a load of 100-500 mf/mL,501-1000 mf/mL, and above 1000 mf/mL, respectively.The overall prevalence of *L. loa* among the total sample was 19.4%. The filarial load distribution for the total population showed; 41.7% had 100-500 mf/mL, 37.5% had 501-1000 mf/mL, and 20.8% with loads above 1000 mf/mL.

Table 2. Prevalence and filarial loads of *Mansonella perstans* and *Loa loa* among study participants

Infection Type	Gender	Category	Frequency Count	Percentage (%)	Filarial Load (mf/mL)	Frequency Count	Percentage (%)
Mansonella perstans infection	Male	Yes	85	47.2	100-500 mf/mL	40	47.1
					501-1000 mf/mL	25	29.4
					Above 1000 mf/ mL	20	23.5
		No	95	52.8	-	-	-
	Female	Yes	80	44.4	100-500 mf/mL	30	37.5
					501-1000 mf/mL	30	37.5
					Above 1000 mf/mL	20	25
		No	100	55.6	-	-	-
	Average	Yes (Total)	165	45.8	100-500 mf/mL	70	42.4
		No (Total)	195	54.2	501-1000 mf/mL	55	33.3
					Above 1000 mf/mL	40	24.2

Loa loa infection	Male	Yes	40	24.7	100-500 mf/mL	25	38.5
					501-1000 mf/mL	20	30.8
					Above 1000 mf/mL	20	30.8
		No	122	75.3	-	-	-
	Female	Yes	30	15.2	100-500 mf/mL	25	45.5
					501-1000 mf/mL	15	27.3
					Above 1000 mf/mL	15	27.3
		No	168	84.8	-	-	-
	Average	Yes (Total)	70	19.4	100-500 mf/mL	50	41.7
		No (Total)	290	80.6	501-1000 mf/mL	45	37.5
					Above 1000 mf/mL	25	20.8

3.3 Knowledge and Awareness of *Mansonella perstans* and *Loa loa*Among the Sampled Participants

Our findings revealed that 70% of participants (252 out of 360) had prior knowledge of either of the infections, indicating moderate awareness levels, while 30% (108 participants) were unfamiliar with these diseases (Table 3). Among those who had some basic knowledge of the diseases, the most common source of information was healthcare providers (33.3%), followed by media (Radio, TV) at 23.8%, indicating that formal health channels are key in raising awareness. Community campaigns and Friends/Family each accounted for smaller portions (21.4% each), emphasizing the role of social networks and public health outreach. Knowledge of symptoms was evenly split, with 50% of participants aware of the symptoms, while the other 50% had no idea of the symptoms. The most commonly reported symptom was fever (35%), followed by skin itching and eye swelling or discomfort (each at 30%), and joint pains (25%). Interestingly, Calabar swellings, a distinctive symptom of *L. loa* infection, was known by only 20% of participants. Additionally, 20% of participants (72 individuals) did not associate any symptoms with these diseases (Table 3).

Table 3. Knowledge and awareness of *Mansonella perstans* and *Loa loa* among the sampled participants

Knowledge and Awareness Variable	Category	Frequency Count (n=360)	Percentage (%)
Ever heard of *M. perstans* or *L. loa* infections?	Yes	252	70
	No	108	30
Source of information about the diseases	Healthcare provider	84	33.3
	Community campaigns	54	21.4
	Media (Radio, TV)	60	23.8

	Friends/Family	54	21.4
Knowledge about the symptoms of *Mansonella perstans* or *Loa loa* infections?	Yes	180	50
	No	180	50
Symptoms of *Mansonella pertans* and *Loa loa*	Skin itching	108	30
	Calabar swellings	72	20
	Joint pains	90	25
	Fever	126	35
	Eye swelling or discomfort	108	30
	None	72	20

3.4 Exposure and Risk Factors for *Mansonella perstans* and *Loa loa*Infections Among the Study Participants

A total of 60% of the participants live or work near swampy areas, rivers, or forests which are common breeding grounds for vectors that transmit these infections (Table 4). A statistically significant association was observed between living in swampy areas, streams and rivers and prevalence (χ^2= 4.15, P =.042, OR=1.45), suggesting that individuals near these environments are 45% more likely to be exposed to infection. Similarly, farming is a significant activity, with 65% of participants engaged in agriculture. There was also a strong association between farming and risk of infection (χ^2= 7.20, P =.007, OR = 1.74), indicating that farmers are 74% more likely to be exposed than non-farmers. Among those engaged in farming, banana farming (30%) was most common, followed by palm oil farming (20%). There was a significant association between banana farming and infection risk (χ^2= 3.95, P =.047 OR =1.62) indicating a 62% higher risk for those involved in banana farming compared to other occupations. Only 35% of participants reported using protective measures. There was a statistically significant association (χ^2= 9.31, P =.002 OR =2.05) between the non-use of protective clothing and infection status, as individuals who do not use protection are over twice as likely to be exposed to infection as those who do. Half of the participants (50%) reported using bed nets.

Comment [EE2]: "Over twice" more appropriate to say "twice"

Table 4. Exposure and risk factors for *Mansonella perstans* and *Loa loa* infections among the study participants

Exposure and Risk Factor	Category	Frequency Count (n=360)	Percentage (%)	Chi-square	p-value	Odds Ratio (OR)
Do you live or work near swampy areas, rivers, or forests?	Yes	216	60	4.15	0.042	1.45
	No	144	40			
Do you engage in farming activities?	Yes	234	65	7.2	0.007	1.74
	No	126	35			
If yes, what type of farming?	Banana farming	108	30	3.95	0.047	1.62
	Palm oil	72	20			

	farming					
	Rubber farming	18	5			
	Others	36	10			
Do you use insect repellent or protective clothing when working outdoors?	Yes	126	35	9.31	0.002	2.05
	No	234	65			
Do you sleep under a bed net at night?	Yes	180	50	1.55	0.213	1.18
	No	180	50			

3.5 Health Status and Medical History of Participants

Of the 360 participants, 20.0% (72 participants) had been diagnosed with one of these infections, while the majority (80.0%) had not been diagnosed (Table 5). This suggests that while the infections were present in the community, the overall prevalence was relatively moderate among the sample population. Among those diagnosed, 50.0%, 25.0%, and another 25.0% were diagnosed between 1 to 3 years ago, less than a year ago, and over 3 years ago, respectively. This distribution indicates that infections have been occurring over time, with some participants having more recent diagnoses. Half of the participants who were diagnosed (50.0%) received anti-parasitic drugs such as ivermectin. Traditional medicine was used by 25.0%, while 16.7% reported not receiving any treatment. A small number of participants (8.3%) indicated receiving other forms of treatment. Forty percent (40%) of participants reported experiencing symptoms such as skin itching, joint pains, or eye discomfort in the past 6 months, while 60.0% did not report such symptoms. Among those who experienced symptoms, 62.5% sought medical care, while 37.5% did not (Table 5).

Comment [EE3]: Is the assumption here parasitological or clinical diagnosis?

Comment [EE4]: What constitutes other forms of treatment?

Table 5. Health status and medical history of study participants

Health Status and Medical History	Category	Frequency Count (n=360)	Percentage (%)
Have you ever been diagnosed with *Mansonella perstans* or *Loa loa* infections?	Yes	72	20
	No	288	80
If yes, when were you diagnosed?	Less than a year ago	18	25
	1-3 years ago	36	50
	Over 3 years ago	18	25
How was the infection treated?	Anti-parasitic drugs (e.g., ivermectin)	36	50
	Traditional medicine	18	25
	No treatment received	12	16.7
	Others (Specify)	6	8.3
Have you experienced symptoms	Yes	144	40

such as skin itching, joint pains, or eye discomfort in the past 6 months?	No	216	60
If yes, did you seek medical care?	Yes	90	62.5
	No	54	37.5

3.6 Environmental Factors Associated with *Mansonella perstans* and *Loa loa* Infections Among Study Participants

Half of the participants (50%) live near water bodies (Table 6). There was a statistically significant association (χ^2= 8.45, P =.004, OR = 2.00) between proximity to water bodies and infection risk. Presence of stagnant water bodies was significantly associated with infection (χ^2= 6.82, P = .009, OR = 1.73), as 60% of participants reported stagnant water or bushes near their homes. Indicating that participants with stagnant water or bushes around their homes are 73% more likely to be exposed to the infections than those without such environmental conditions. The majority of participants (70%) practice some form of environmental sanitation. Sanitation practices were significantly associated with a lower risk of infection (χ^2= 5.37, P =.021, OR = 1.83), indicating that those who do not practice sanitation are at higher risk. Only 15% of participants clean their surroundings daily, while the majority (40%) clean weekly. There was a significant association between cleaning frequency and infection risk (χ^2= 11.12, P =.011). Those who clean their surroundings daily are almost twice as likely to reduce their infection risk (OR = 1.92) compared to those who clean less frequently or never (Table 6).

Table 6.Environmental factors associated with *Mansonella perstans* and *Loa loa* infections among study participants

Environmental Factors	Category	Frequency Count (n=360)	Percentage (%)	Chi-square	p-value	Odds Ratio (OR)
Is your living environment near water bodies (rivers, lakes, swamps)?	Yes	180	50	8.45	0.004	2
	No	180	50			
Are there stagnant water pools or bushes around your home?	Yes	216	60	6.82	0.009	1.73
	No	144	40			
Do you practice any form of environmental sanitation?	Yes	252	70	5.37	0.021	1.83
	No	108	30			
How frequently do you clean your surroundings?	Daily	54	15	11.12	0.011	1.92
	Weekly	144	40			
	Monthly	90	25			
	Rarely	54	15			
	Never	18	5			

Comment [EE5]: What constitutes any form of environmental sanitation? This could help in direct association and help readers know which practices greatly reduce risk.

3.7 Socioeconomic Factors Related to *Mansonella perstans* and *Loa loa* Infections Among Study Participants

We found out that 40.0% of participants earn less than 50,000 CFA monthly, followed by 30.0% earning between 50,000 and 100,000 CFA, 20.0% earning between 100,000 and 200,000 CFA, and 10.0% earning over 200,000 CFA (Table 7). We found a statistically significant association between lower income and infection risk (χ^2= 9.32, P =.025, OR = 2.10), with individuals earning less than 50,000 CFA more than twice as likely to be at risk of infection compared to those with higher incomes. A majority (55.0%) of participants reported that their financial situation affects their ability to access healthcare services, while 45.0% stated otherwise. There was a strong association between participants facing financial challenges and infection (χ^2= 11.57, P=.001, OR=2.32), as participants facing financial challenges were more than twice as likely to face barriers in accessing healthcare, putting them at greater risk of complications from untreated infections. Only 2.7% of participants reported having access to health insurance, while 97.3% did not have insurance coverage (Table 7). We found a significant relationship between lack of health insurance and higher risk of infection (χ^2= 8.74, P =.003, OR=2.15). This suggests that participants without health insurance are more than twice as likely to experience difficulties in managing infections due to limited access to healthcare services.

Table 7.Socioeconomic factors related to *Mansonella perstans* and *Loa loa* infections among study participants

Socioeconomic Factors	**Category**	**Frequency Count (n=360)**	**Percentage (%)**	**Chi-square**	**p-value**	**Odds Ratio (OR)**
Estimated monthly income	Less than 50,000 CFA	144	40	9.32	0.025	2.1
	50,000-100,000 CFA	108	30			
	100,000-200,000 CFA	72	20			
	Over 200,000 CFA	36	10			
Does your financial situation affect your ability to access healthcare services?	Yes	198	55	11.57	0.001	2.32
	No	162	45			
Do you have access to health insurance?	Yes	10	2.7	8.74	0.003	2.15
	No	350	97.3			

3.8 Preventive Measures and Attitudes Towards *Mansonella perstans* and *Loa loa*Infections Among Study Participants

A majority (70.0%) of participants believed that *M. perstans* or *L. loa* infections are preventable, while 30.0% did not (Table 8). There was a statistically significant association between perception and preventive behavior(χ^2= 7.21, P = .007, OR = 2.10). This suggests that individuals who think that these infections are preventable are twice as likely to take action to prevent them compared to those who do not. The most commonly reported measure was the use of bed nets (60.0%), followed by wearing long-sleeved clothing (30.0%), and using insect repellents (20.0%). The use of bed nets was significantly associated with reduced infection risk (χ^2= 6.54, P = .011, OR=1.85). This means that those using bed nets are 85% more likely to avoid insect bites that may cause infection. However, 15.0% reported using no preventive measures at all, indicating potential gaps in awareness or resources. Only 40.0% of participants had participated in a community campaign or health education program on parasitic diseases. Participation in health campaign programmes was significantly associated with improved preventive behavior (χ^2= 5.80, P= .016, OR=1.73). Ten percent (10%) of participants visit health facilities frequently for general check-ups, while the majority visit occasionally (40.0%) or rarely (35.0%) (Table 8). Frequent check-ups are strongly associated with a reduced risk of infection (χ^2= 9.23, P =.002, OR=2.47). This shows that participants who frequently visit health facilities are more than twice as likely to manage potential health issues early, compared to those who visit rarely or never.

Table 8. Preventive measures and attitudes towards *Mansonella perstans* and *Loa loa* infections among study participants

Preventive Measures and Attitudes	Category	Frequency Count (n=360)	Percent age (%)	Chi-square	p-value	Odds Ratio (OR)
Do you think *Mansonella perstans* or *Loa loa* infections are preventable?	Yes	252	70	7.21	0.007	2.1
	No	108	30			
What preventive measures do you use against insect bites?	Use of bed nets	216	60	6.54	0.011	1.85
	Wearing long-sleeved clothing	108	30			
	Using insect repellents	72	20			
	None	54	15			
	Others (Specify)	18	5			
Have you ever participated in a community campaign or health education program on parasitic diseases?	Yes	144	40	5.8	0.016	1.73
	No	216	60			
How often do	Frequently	36	10	9.23	0.002	2.47

you visit health facilities for general health check-ups?	Occasionally	144	40			
	Rarely	126	35			
	Never	54	15			

4. DISCUSSION

The distribution of various sociodemographic constructs such as age, gender, education, and occupation in our study aligns with some patterns observed in other regions of Cameroon, West and Central Africa. The predominance of the 21-35 and 36-55 age groups is similar to findings in rural Cameroon, where these age groups are often more exposed to outdoor activities and agricultural work, which increases their risk of parasitic infections [14]. The slight female majority (55%) also reflects demographic trends seen in rural health surveys, as women are often more involved in family healthcare decisions [28]. The high proportion of farmers and students (25% each) is consistent with agricultural districts in West Africa, where farming is the dominant occupation, and young people form a significant portion of the population [29]. The educational background shows moderate literacy, with 40% having completed secondary education, aligning with rural educational statistics in Central African countries where access to higher education is limited [30]. The mix of urban, semi-urban, and rural residents (40%, 30%, and 30%) reflects the ongoing urbanization trends in Cameroon, as observed in national census reports.

The findings from our study, which report a 45.8% prevalence of *M. perstans* and a 19.4% prevalence of *L. loa* infections in the Njombe-Penja health district, highlight the significant burden these parasitic diseases pose to the area. Our reported prevalence of *M. perstans* is consistent with studies of Wanji et al. [10], who found a 47% prevalence in Cameroon's Southwest region, and Tchoumi and et al. [31], who reported similar rates in Cameroon's Eastern region. These results also confirm that *M. perstans* remains a substantial public health issue in Cameroon. Similarly, the 19.4% prevalence of *L. loa* we observed is in contrast with the 32% prevalence found by Zouré et al. [17]in Southern Cameroon and Pion et al. [32],in Gabon, where the prevalence of *L. loa* ranged from 30% to 35%, emphasizing that though with lower prevalence *L. loa*, is still a widespread and persistent infection in Njombe-Penja and Central Africa.

When compared to studies outside Cameroon, such as those conducted in Congo-Brazzaville and Ghana, where *M. perstans* prevalence ranges between 20% and 40% depending on the region [36], our findings reflect a higher prevalence in Njombe-Penja, possibly due to specific environmental and agricultural factors like proximity to water bodies, poor sanitation and large scale banana farming, which facilitate the breeding of insect vectors. Basáñez et al. [37] emphasize the importance of environmental factors in determining filarial infection risks, particularly in rural, swampy regions.

Gender-wise, the findings from this study, showing a *L. loa* infection prevalence of 24.7% in males and 15.2% in females, align with several studies in Cameroon and other Central and West African regions. For example, a study by Akue et al. [23, 34] in Gabon reported similar trends, where males exhibited higher prevalence due to their increased exposure to the vectors in outdoor occupations like agriculture. Our results however, align with Wanji et al. [9], who also noted relatively equal gender distribution in *M. perstans* infections, suggesting that both men and women are equally exposed to vectors in rural areas. The near-equal gender prevalence observed in our study could be due to similar patterns of exposure in the population studied, particularly since both males and females engage in farming or live near vector-prone environments.

The filarial load distribution, where the majority of individuals had microfilariae loads between 100-500 mf/mL, mirrors findings from studies such as those by Wanji et al. [9], which showed similar parasite loads among infected populations in rural Cameroon. These comparisons suggest that occupational exposure and environmental factors play a significant role in *L. loa* transmission patterns in Central Africa, and the consistency in microfilariae load distribution across various studies points to common epidemiological trends across endemic regions. Our study also provides insights into the filarial load distribution, which shows that more than 40% of infected individuals had moderate filarial loads (100–500 mf/mL), while around 25% had loads above 1000 mf/mL. These findings are comparable to those in Tanzania by Kipasa et al. [35] who found that 35% of individuals infected with *L. loa* had filarial loads above 500 mf/mL. High filarial loads are particularly worrisome because they are associated with an increased risk of severe clinical symptoms and complications. In particular, individuals with *L. loa* microfilariae densities above 1000 mf/mL are at risk for serious adverse reactions to drugs like ivermectin, a problem that was highlighted by Zouré et al. [17]

Our study found that 70% of participants were aware of *M. perstans* and *L. loa* infections, aligning with other findings in sub-Saharan Africa. For instance, Wanji et al. [18] reported a similar awareness level of 72% in Cameroon. However, the lack of detailed knowledge about symptoms, with half of the participants unable to identify any, mirrors results from other studies. Zouré et al. [17], for example, observed that while general awareness was high in Southern Cameroon, only 40% of participants could recognize key symptoms like Calabar swellings. This gap in symptom recognition is critical because it hampers early diagnosis and treatment.

Healthcare providers were a major source of information in our study, which is consistent with Tchoumi et al. [31], who emphasized the central role of healthcare professionals in educating populations about parasitic infections. However, Pion et al. [38] noted that while healthcare professionals are essential, media campaigns also play a significant role in raising awareness, which our study supports, as media was identified as a secondary source of information. The findings underscore the need for public health campaigns to emphasize the distinctive symptoms of these infections to improve early detection and treatment, a conclusion also drawn by Gyapong et al. [39] in Ghana.

Our study found that 20% of participants have previously been diagnosed with *M. perstans* or *L. loa*, similar to Pion et al. [34], who reported a 17% prevalence in Gabon. The reliance on anti-parasitic drugs like ivermectin reflects the findings of Tchoumi et al. [31] in Cameroon, where formal healthcare is accessible. However, the use of traditional medicine by 25% of participants is consistent with Nchinda et al. [40], who observed a reliance on alternative practices in rural Cameroon. The high percentage of symptomatic individuals not seeking care (37.5%) aligns with Gyapong et al. [36], highlighting gaps in healthcare accessibility.

Our study demonstrates the significant impact of environmental factors on the risk of *M. perstans* and *L. loa* infections, particularly regarding proximity to water bodies and stagnant water, which serve as breeding grounds for vectors. These findings align with those of Demanou et al. [41], who reported a higher prevalence of filarial infections in areas near water bodies in Cameroon. Similarly, Wanji et al. [18] found that poor environmental sanitation significantly increased infection risks in filaria-endemic regions. Our observation that daily sanitation reduces infection risk is consistent with Boussinesq et al. [27], who emphasized the effectiveness of environmental hygiene practices in lowering vector density and transmission rates. In contrast, areas with poor environmental management were reported by Pion et al. [38]to have persistent high infection rates despite health interventions.

The socioeconomic factors examined in our study mirror the findings of previous research on parasitic infections in resource-limited settings. Our data shows that low-income individuals, especially those earning less than 50,000 CFA, face increased risk of *M. perstans* and *L. loa* infections due to barriers in accessing healthcare, which is consistent with Biritwum et al. [41]. They also found that financial constraints significantly impacted timely treatment for lymphatic filariasis in Ghana. Similarly, Bauhoff et al. [43]highlighted the role of financial insecurity in limiting access to healthcare services, reinforcing our finding that 55% of participants cite financial challenges as a barrier to care. The lack of health insurance coverage as a risk factor is well-documented. Njoroge et al. [30]in Kenya observed that uninsured individuals were less likely to seek timely diagnosis and treatment for parasitic infections, which aligns with our finding of a significant association between lack of insurance and higher infection risk. The odds ratio of 2.32 in our study suggests a similar magnitude of risk due to financial challenges, supporting Ndugga and Artiga [15]who emphasized the need for expanded insurance coverage to improve healthcare access and outcomes in underserved populations.

The findings from this study align with other research emphasizing the importance of preventive measures in reducing *M. perstans* and *L. loa* infections. For instance, Tchouassi et al [44]reported that the use of insecticide-treated bed nets significantly reduced the exposure to vector-borne infections in rural Cameroon, which corroborates our findings on the protective effect of bed net use. Similarly, Kolaczinski et al. [28] highlighted that public health education campaigns are critical in improving community knowledge and participation in preventive measures, echoing our results that show health campaigns contribute to better protective behaviors. The gap identified in our study, with 15% of participants not using any preventive measures, resonates with the findings of Mbah et al. [45], who reported that resource constraints and lack of awareness were the primary reasons for the underutilization of bed nets in Nigeria. Our study also shows that frequent health check-ups reduce infection risk, which is supported by Simonsen et al. [6], who found that regular screening in endemic areas helped detect and treat parasitic infections earlier.

5. CONCLUSION

This study conducted in the Njombe-Penja health district reveals a high prevalence of *M. perstans* and *L. loa* infections, with 45.8% of participants infected by *M. perstans* and 33.3% infected by *L. loa*. These findings indicate that both parasitic infections are endemic in the region, posing significant public health challenges. The prevalence is notably higher among males for both infections, with 47.2% of men infected by *M. perstans* and 36.1% by *L. loa*, compared to 44.4% and 30.6%, respectively, among females. Filarial load analysis shows that a significant proportion of infected individuals carry moderate to high parasite burdens, with up to 24.2% of *M. perstans* and 20.8% of *L. loa* patients having filarial loads above 1000 mf/mL. These heavy parasitic burdens are particularly alarming, as they are associated with increased risk of clinical complications and adverse reactions to treatment, especially in individuals infected with *L. loa*.

The study also identified several associated risk factors for the high infection rates. One key factor is the proximity of many participants to swampy areas, rivers, and forests, environments conducive to the vectors that transmit these parasites. Furthermore, farming activities, especially in banana, palm oil, and rubber farming were linked to greater exposure to infected vectors, as many farmers work outdoors without protective measures. Additionally, the lack of consistent use of insect repellents, protective clothing, and bed nets further exacerbates the risk of infection. The presence of stagnant water and poor environmental sanitation around homes contributes to the breeding of disease-carrying insects, increasing the likelihood of transmission.

Given the high prevalence and associated risks, urgent interventions are needed to control these infections in the district. Mass drug administration (MDA) programs should be prioritized to reduce the burden of both *M. perstans* and *L. loa*. Due to the significant filarial load in many individuals, particularly for *L. loa*, careful screening should precede treatment to avoid severe adverse reactions to medications like ivermectin. Moreover, there is a clear need for vector control measures, including the distribution of insecticide-treated bed nets, promotion of insect repellents, and encouragement of protective clothing for those working outdoors. Environmental sanitation efforts, such as clearing stagnant water and reducing vegetation near homes, are essential to limit the breeding of vector insects. Health education campaigns must also be implemented to increase awareness about the transmission, symptoms, and prevention of parasitic infections.

CONSENT (WHEREEVER APPLICABLE)

After explaining the objectives and relate issues of the study to the participants, a section was provided for them to indicate by signing, their willingness to participate in the study.

I, the undersigned Mr/Ms ______________________________________, residing in ____________________________________ community, certify that I have read the information above concerning the objectives and conduct of the study by the team of the University of Buea, or that the information was read to me. I have had the opportunity to ask questions and all of the questions I asked were answered. I agree to participate in the study and I know that I can withdraw from the study any time I want. I have received a copy of the information document.

Signature of participant: ______________________________

Date: __________________   Place: ____________________

ETHICAL APPROVAL (WHEREEVER APPLICABLE)

An ethical approval for this study, as seen in the appendix, was obtained from the ministry of public health in Yaounde.

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