Journal of Diseases
2019 Vol. 6, No. 2, pp. 81-89
ISSN(e): 2410-6550
ISSN(p): 2413-838X
DOI: 10.18488/journal.99.2019.62.81.89

DETERMINANT FACTORS AND SPATIAL DISTRIBUTION OF VISCERAL LEISHMANIASIS IN NORTH GONDAR IN SELECTED HOSPITALS

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Article History
Received: 18 July 2019
Revised: 21 August 2019
Accepted: 24 September 2019
Published: 12 November 2019

Keywords
VL
Moran's I Ord and GetisGi.
Cluster
Prevalence
Hot spot
Cold spot.

ABSTRACT

Introduction: Visceral Leishmaniasis (VL) is a neglected tropical disease caused by Leishmaniasis protozoa, and transmitted by a sand fly vector. Leishmaniasis is distributed in worldwide and affects millions of peoples. Objective: The objective was to assess the prevalence and spatial distribution of VL in North Gondar. Methodology: 369 patients were selected from records or medical charts retrospectively using stratified and systematic sampling techniques. The study used spatial autocorrelation measures and auto logistic regression model. Result: From 369 patients, 313 (84.8%) were infected by VL. The proportion of VL incidence for those who traveled to endemic areas was (70.2%). Male patients accounted a larger proportion (93.2%) compared to female patients (6.8%). Moran's scatter plot test revealed there is regional clustering on the VL incidence. Local Moron's Index value of Gondar Zuria, Dembeya, Quara, Metemma, Tach Armachiho, Gondar Town, West Belesa and Adarakay was positive, this showed places that shared boundaries have similar VL incidence (i.e high-high or low-low). From result of local Getis and Ord statistic, positive standardized Z-values of Adarkay, Gondar Town, Metema, Quara, West Belesa and Dembiya showed the places were hot spot. Similarly negative standardized Z values of Gondar Zuria and Tach Armachiho revealed that places were cold spot. The spatial auto logistic regression result revealed that sex, travel history, BMI, rainfall and elevation were the significant factors of VL at 95% confidence level. Conclusion: The prevalence of VL is still very high (84.8%) in North Gondar Zone. VL clustered on endemic districts that shared common boundaries.

Contribution/Originality: This study contributes in the existing literature, spatial distribution and determinant factors of visceral leishmaniasis in North Gondar. Spatial auto logistic regression model is the new approach which helps to determine the prevalence and correlates of visceral leishmaniasis on the study area. VL is clustered on shared boundaries.

Abbreviations:

(ESDA) Explanatory Spatial Data analysis, (GIs) Geographical Information System, (VL) Visceral Leishmaniasis, (WHO) World Health Organization, (LMI) Local Moron's Index.

1. INTRODUCTION

Kalazar is a chronic and fatal parasitic disease, and transmitted by the bite of female sand flies. The three forms of leishmaniasis are called cutaneous, mucocutaneous, and visceral [1]. Visceral leishmaniasis epidemics continues killing of thousands of people on Asia and Africa. From the estimated 1.6 million cases, 600,000 diagnosed and treated each year [2].

In Eastern Africa there are 30,000 - 40,000 new cases per year, it is the highest number of VL cases following the Indian Subcontinent. Major epidemics of VL have affected different part Africa (Eritrea, Ethiopia, Kenya, Somalia, Sudan, South Sudan, and Uganda) [3]. VL is still endemic and highly prevalent in Ethiopia, with over 3.2 million peoples at risk and estimated up to 4000 new cases per year [3]. In the lower Omo plains (southwestern part of the country) the first case of VL was recorded in 1942. The disease has become widespread over the country. Humera, the Omo plains, the Aba Roba focus, Metema plains and the Weyto River Valley in the southwest are the places where VL mostly found. VL also occurred in the highlands of Libokemkem Amahara region in 2003 [4].

As demonstrated on different studies VL occurs mostly on the North-West Ethiopia. Semiarid Metemma, Humera, and the bordering of Sudan are areas where incidence mostly occurs [5]. There are around 5,000 new VL cases in Ethiopia as estimated by the Ministry of health of Ethiopia.

Domestication of the transmission cycle, the incursion of agricultural farms, urbanization, and settlements into forested areas are the major environmental changes that affect the incidence of leishmaniasis. And also land degradation and Global warming are the other factors for the epidemiology of leishmaniasis [5].

Even though the visceral leishmaniasis range is very broad, it is not continuous. It is clustered on the places exposed for drought, peoples with famine, and large population density. Much information is needed about the spatial distribution of leishmaniasis and its pattern. The epidemics on the shared common boundaries, the hot and cold spot areas, and the range of endemic areas are not known exactly. These problems let the prevention and control mechanisms very difficult, and give a chance of expansion to the disease. Therefore, this study mainly aimed to assess the spatial distribution of the visceral Leishmaniasis disease. On the way, covariates of VL were identified by spatial auto logistic regression model.

2. DATA AND METHODOLOGY

2.1. Study Area Description

The study was conducted on three hospitals (Gondar Referral Hospital, Metema Hospital, and Abderafi health center) in North Gondar Zone from January to February, 2018. North Gondar is located in Amahara Regional State, Ethiopia. It is named for the city of Gondar, the capital of Ethiopia until the mid-19th century. The study included all patients who had been suspected for visceral leishmaniasis infection test at the time of their visit.

2.2. Study Design

A retrospective study was implemented using the hospitals database records or medical charts. It includes patients suspected for leishmaniasis in one year period.

2.3. Sampling Technique and Sample size

Since the population is heterogeneous; in this study stratified random sampling was used. Participants in each stratum were selected by systematic random sampling from the recorded database or medical charts. Sample size of 369 patients was selected from total records of 9319.

2.4. Data Management and Analysis

Data were first entered, and checked by SPSS version 20, and analyzed using R, Geoda and ARC GIS software's. Global and local tests were used to measure spatial autocorrelation of VL incidence. Spatial auto logistic regression model was also implemented to identify different socio-economic and demographic covariates of VL incidence. Variables whose p-value less than 0.05 were considered as statistically significant.

2.5. Methodology of the Study

Global and local spatial autocorrelation tests were used to measure correlation of a variable with itself through space.

Measures of spatial autocorrelation can be both global and local. A global statistics looks at the entirety of a study area and provides a single output, such as if the data displays clustering but doesn't show clusters existence. Local statistics look within the data, in this case clustering or dispersion as compared to particular locations' neighbors and provides visualization of where that clustering is occurring [6].

Spatial auto-logistic models were also used to identify the determinant factors of *visceral leishmaniasis*. The auto logistic regression is the most widely used one for modeling spatially correlated presence/absence of data. Indeed, many studies have demonstrated the usefulness of the auto logistic regression in modeling binary data with observed covariates. The auto logistic regression model is a special case of the general logistic models. The model introduces a spatial autocorrelation term in the form of weighting coefficients and solves the problem of spatial autocorrelation effects in the process of statistical analysis.

3. RESULTS

3.1. Descriptive Statistics

From a total of 369 suspected patients 313 (84.8%) were with visceral leishmaniasis and 56 (15.2%) without visceral leishmaniasis during the study Table 1. Of this 235(63.7%) of the patients lived in rural and 134 (36.3%) lived in urban. Patients who were males accounted a larger (93.2%) proportion in the sample compared to patients who were females (6.8%).

Patient who traveled to endemic area (70.2%) have high proportion of visceral leishmaniasis incidence than the patient who did not traveled to the endemic area (29.8%). Visceral leishmaniasis incidence mostly occurred from December to February (36.3%) while the lowest occurrence time was September to November (14.9%). Patients who have Co-infected disease (24.9%) had low proportion of visceral leishmaniasis incidence than the Patients that have not Co-infected disease (75.1%) Table 1.

Table-1. Summary of variables.

Variable		Frequency	Percent
Visceral leishmaniasis	Yes	313	84.8
	No	56	15.2
Sex	Female	25	6.8
	Male	344	93.2
Travel history	Yes	259	70.2
	No	110	29.8
Residence	Rural	235	63.7
	Urban	134	36.3
month of occurrence	September –November	55	14.9
	December-February	134	36.3
	March-May	122	33.1
	June-August	58	15.7
Co-infected disease	Yes	93	25.2
	No	276	74.8

Source: Summarized from medical charts of Gondar Referral Hospital, Metema Hospital, and Abderafi health center.

3.2. Exploratory Spatial Data Analysis (ESDA) Results

A positive Moran's I value (0.20) from the Moran Scatter plot revealed the existence of global spatial autocorrelation Figure 1.

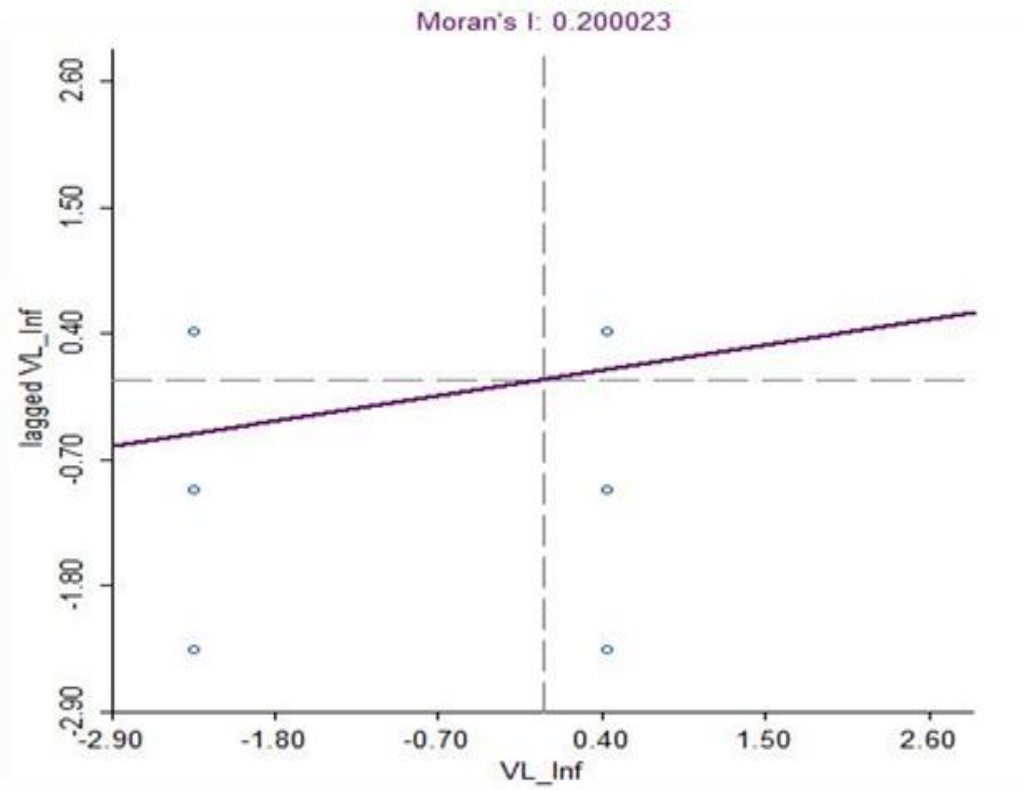

Figure-1. Univariate Moran's scatter plot for visceral leishmaniasis disease incidence.
Source: Summarized from medical charts of Gondar Referral Hospital, Metema Hospital, and Abderafi health center.

3.3. Local Moran's Index (LMI)

Local Moron's Index values Table 2 of Gondar Zuria, Dembeya, Quara, Metemma, Tach Armachiho,Gondar Town, West Belesa and Adarakay woredas are 2.58, 3.25, 2.24, 3.67, 2.29,4.003, 3.30 and 4.001 respectively; these values are positive and significant at 95% level. These values indicated a given districts surrounded by districts with similar disease occurrences (either High-High or Low-Low).

Table-2. Local Moron's I index result of visceral leishmaniasis disease incidence

Woreda	LMi index	LMiZ-score	LMiP-value
Gondar Zuria	0.001	2.577	0.010
Dembeya	0. 002	3.250	0.001
Quara	0. 001	2.243	0.025
Metemma	0. 001	3.668	0.001
TachArmachiho	0.001	2.291	0.022
Chliga	-0.001	-2.563	0.010
Lay Armachiho	-0.001	-2.703	0.007
Gondar Town	3.992	4.003	0.001
West Belesa	0.001	3.297	0.001
Wogera	-0.001	-3.006	0.003
Debark	-0.001	-1.991	0.047
Janamora	-0.001	-2.671	0.008
Adarakay	0.001	4.001	0.001

Source: Summarized from medical charts of Gondar Referral Hospital, Metema Hospital, and Abderafi health center

3.4. Local ORD and GETIS Gi Statistics*

The local statistics, Gi and Gt, enable us to detect pockets of spatial association that may not be evident when using global statistics. The G statistic distinguishes between hot spots and cold spots. From result of local Getis and Ord statistic Table 3 the standardized Z values of Adarkay, Gondar Town, Metema, Quara, West Belesa and Dembiya were 2.23, 2.64, 2.216, 2.35, 2.65, and 1.3 respectively; these values were positive and significant at α =0.05. This showed these places are hot spot areas. Similarly the standardized Z values of Gondar Zuria and Tach Armachiho were -2.82 and -2.05 respectively; these values were positive and significant at α =0.05. This showed these areas are very cold spot.

Table-3. Results of Local Gi* test statistics.

Woreda	Z-score	p-value
Adarakay	2.226	0.026
Chliga	0.902	0.367
Debark	-0.167	0.867
Dembeya	1.300	0.019
Gondar Town	2.635	0.008
Gondar Zuria	-2.824	0.005
Janamora	-0.751	0.452
Lay Armachiho	0.776	0.438
Metemma	2.161	0.013
Quara	2.350	0.019
Tach Armachiho	-2.045	0.041
West Belesa	2.645	0.008
Wogera	-1.330	0.183
Alefa	-0.785	0.432
Takusa	0.752	0.451
East Belesa	0.269	0.788
Beyeda	1.570	0.116
Telemt	-1.300	0.194
Tegede	0.152	0.879
West Armachiho	0.871	0.383

Source: Summarized from medical charts of Gondar Referral Hospital, Metema Hospital, and Abderafi health center.

In addition, the results from Table 4 showed the z-score value is positive; so the observed General G index is larger than the expected General G index, this indicates that high values for the attribute are clustered in the North Gondar area.

Table-4. General G summary result of visceral leishmaniasis incidence.

Statistic	Value
Observed general G	0.001
Expected general G	0.001
Variance	0.001
z-score	1.200
p-value	0.023

Source: Summarized from medical charts of Gondar Referral Hospital, Metema Hospital, and Abderafi health center.

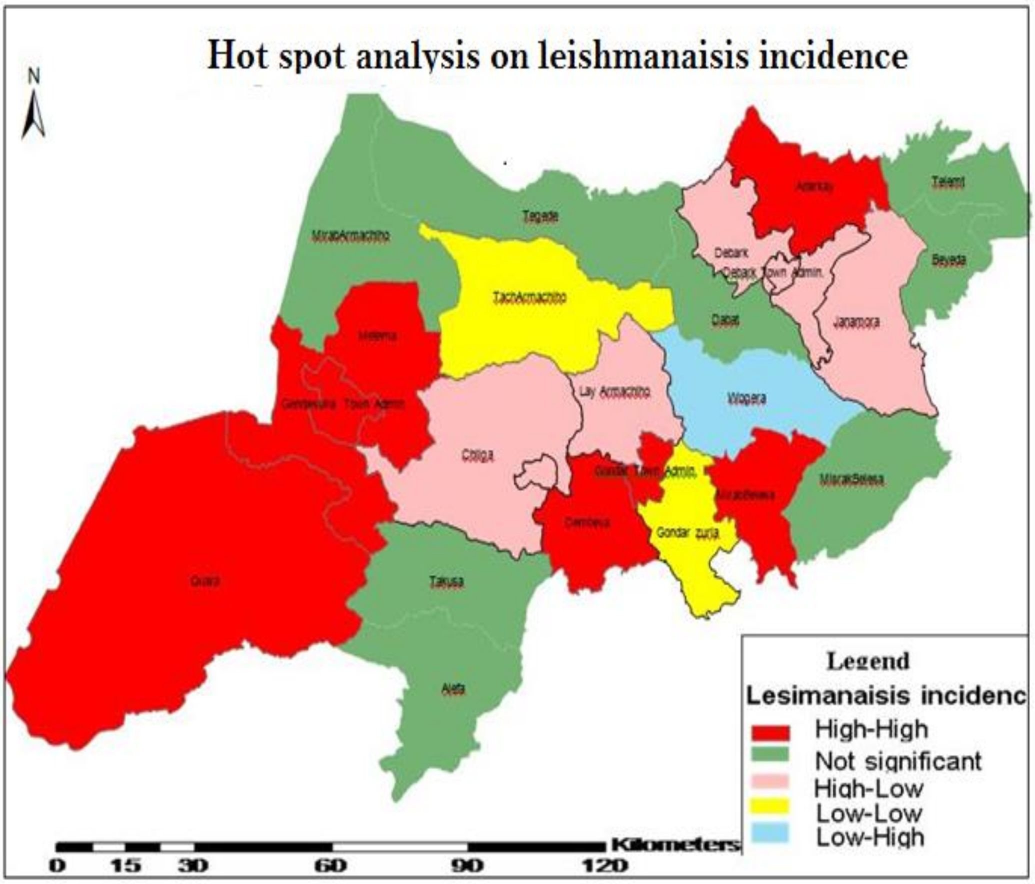

Figure-2. Gi* clustering map of visceral leishmaniasis incidence in North Gondar.
Source: Summarized from Gondar Referral Hospital, Metema Hospital, and Abderafi health center.

Woredas with significant clustering and dissimilar (outliers) can be expressed by using cluster mapping. As we have seen from Figure 2 the red colored districts, Quara, Metema, West Belesa,Adarkay, Gondar town and Denbia had high VL prevalence, and these values were similar with these places shared boundaries . The yellow colored districts, Tach Armachiho and Gondar zuria had lower VL prevalence, which were similar to their shared boundaries. The rose colored i.e Janamora, Lay Armachiho, Chilga and Debark were indicators of districts with high value surrounded by districts with low values. Wogera district (lower VL prevalence) was surrounded by higher VL prevalence districts. Whereas the green colored part of Alefa, Takusa, Beyeda ,East Belesa, Telemt,Tegede, West Armachio and Dabat districts were not significant areas.

The result of spatial auto logistic regression model showed that sex, travel history, BMI, rainfall and elevation were the determinant factors of VL at 95% confidence level Table 5.

Table-5. Summary of spatial auto logistic regression model.

Variables		Estimate	Std. err	Z-value	P-value
Intercept		1.51405972	1.20670817	1.255	0.21
Sex	female(Ref)				
	male	3.52713702	0.722	4.886	000 ***
Travel history	yes (Ref)				0.030 *
	No	-1.601	0.734	-2.181	
Rainfall		0.0131	0.005	2.571	0.010 *
BMI		0.044	0.016	2.719	0.007 **
Elevation		-0.001	0.000	-4.449	000 ***

Ref in the brackets indicates the reference category of each explanatory variables.

The odds of VL presence for male patients were 34.1 times than those patients who were female. This indicated that the presence of VL is more likely to occur on males than females. Odds ratio for travel history indicated that patients who were not traveling to the endemic areas had 80% less chance to be exposed by VL than those patients who were traveling to endemic areas Table 5.

The effect of BMI, rainfall and elevation on the VL occurrence was different in the study area. As the BMI increased by 1 kg, the odds of visceral leishmaniasis incidence increased by 0.04 holding the values of other explanatory variables constant. As the average annual rain fall increased by 1 rain gage, the odd of visceral leishmaniasis increased by 0.01 holding the values of other explanatory variables constant. As the elevation increased by 1m, the odds of visceral leishmaniasis incidence decreased by 0.001 holding the values of other explanatory variables constant Table 5.

The comprehensive effect of the climate and social-economic factors made the regression model to have more convincing power and application value. In addition, the auto covariate variable also plays an important role in the auto logistic model. It showed epidemiology of VL had significant relation with the spatial location.

4. DISCUSSIONS

Nearby locations are likely to possess similar attributes. In other words, everything is related to everything else, and nearby things is more closely related to nearby things than to distant things.

In epidemiology, a cluster becomes apparent when a number of health events occur which are situated close together in space and/or time. Spatial autocorrelation is defined as the relation between the values of a single variable. This relation is attributable to the geographic arrangement of areal units on a map and can be used to identify the degree of spatial clustering.

In this study, the local G-statistic is used to measure the degree of spatial clustering and map the geographic patterns of the areal units. For this reason, this study showed that Quara, Metema, West Belesa, Adarkay, Gondar town, and Dembia were hot spots of VL incidence; on the other hand Tach Armachiho and Gondar Zuria were cold spots of VL incidence.

Information about spatial location is useful for detecting risk factors from a spatial viewpoint. The autoregressive parameter estimate was positive and significant which indicated that there is spatial spillover in visceral leishmaniasis incidence. This study found that travel history had a significant association with the incidence of VL in the districts of the regions at a 95% level. The auto logistic result also revealed that sex, travel, history, BMI, rainfall and elevation were significant factors of VL incidence.

The finding of this study revealed that males VL patients accounted a larger (93.2%) proportion compared to female VL patients (6.8%). This result also supported by Sarah, et al. [7]; Perry, et al. [8].

A lot of literatures have also proven that a tremendous importance for greatly affecting the incidence of visceral leishmaniasis. This result is consistent with what was discussed in the literature review by Bugssa, et al. [9] that showed travel history to the endemic area was significant factor for the incidence of visceral leishmaniasis disease. And also this finding supported by the study conducted by Tamalee, et al. [10].

In this study, elevation and rainfall were the significant factors for visceral leishmaniasis disease within the district at 95% confidence level, which is supported by [9-11].

5. CONCLUSIONS

Conclusion: The prevalence of VL is still very high (84.8%) in North Gondar Zone. VL clustered on endemic districts that share common boundaries. This may be one of the reasons for the spread of the disease. Detail research should be conducted on this area. People traveling to incidence areas, and those who live on rural areas should have awareness on how to prevent themselves from the bite of fly during working, walking, and sleeping time. Further spatial analysis study on the other endemic wereda and Zones, would help to know the range of incidence and to control it.

6. RECOMMENDATIONS

The finding of this study showed that a higher visceral leishmaniasis incidence in one district will tend to push up the visceral leishmaniasis incidence to other districts. Based on the study finding, the following issues recommended.

- Investments on infrastructures and health treatment facilities should be based on the need of each wereda.
- Policy makers and concerned bodies should take some measures to undertake migration due to labors in endemic area.
- Peoples traveling to very hot spot areas (Adarkay, Gondar Town, Metema, Quara, West Belesa and Dembiya) should have awareness about the epidemiology of VL.

Funding: This study received no specific financial support.
Competing Interests: The authors declare that they have no competing interests.
Acknowledgement: All authors contributed equally to the conception and design of the study.

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