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The Relationship between Climatic Factors and the Prevalence of Visceral Leishmaniasis in North West of Iran

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Abstract

Background
Visceral leishmaniasis (VL) is most commonly found among children under the age of 10 in some provinces of Iran including Ardabil. As such, this study set out to determine the relationship between some climatic factors and the prevalence of VL in Northwest of Iran.

Materials and Methods
In this descriptive-analytic study, data collection was done on some climatic factors including rainfall, temperature, and the number of sunny and snowy days from Apr. 2001 to Sep. 2017 from the weather station in Meshkinshahr County of Ardabil province, Iran, and the related information of the VL patients from the health center. Statistical analysis was done using Excel and SPSS version 23.0 software. Pearson correlation coefficient test was utilized for data analysis.

Results
Over the course of 17 years, 226 cases of VL occurred in rural and urban areas of Meshkinshahr. The highest prevalence of VL disease was reported in February and March. Climatic factors of temperature and the number of sunny days showed a direct relationship with the prevalence of VL disease ($P<0.05$). However, rainfall and the number of snowy days had inverse correlation with the prevalence of VL ($P>0.05$).

Conclusion
In spite of the rather cold and humid climate of Meshkinshahr County during much of the year, based on the findings of present study, there was a significantly direct relationship between VL disease and the hot temperature as well as sunny days.

Key Words: Climatic factors, Iran, Visceral leishmaniasis.

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1- INTRODUCTION

Visceral leishmaniasis (kala-azar, VL) is an important infectious disease which is caused by a variety of *leishmania donovani complex*. The causative agent of disease in the widespread Mediterranean region, including Iran, is *Leishmania infantum*, and its second etiologic agent is *leishmania tropica* (1). The main reservoirs of this disease in Iran are dog and canidae family (2) and the vectors are various species of sand flies, including *phlebotomus major*, the dominant species in Iran (3). In the absence of a diagnosis and timely treatment of the disease in humans, the disease can have a maximum case fatality rate of 98%, especially in children (4). Currently, leishmaniasis is endemic in 98 countries across 5 continents; including Asia, Europe, Africa and the United States (5). Among them 72 are developing countries and 13 under-developed countries (6).

The prevalence of this disease is 12-14 million cases in the world and its annual incidence is 1.5-2 million cases. There are about 500,000 new cases of VL happening every year in the world. According to WHO reports, more than 350 million world people are living in high-risk areas exposed to a variety of leishmaniasis. Approximately 90% of VL disease is reported from 5 countries, including Bangladesh, India, Sudan, Nepal and Brazil. According to official reports, the annual mortality rate due to VL was 59,000 cases (7). In Iran, VL is characterized as the Mediterranean type of disease whose agent is a parasitic infection found mostly among children under the age of 10 and is endemic in some provinces of the country (8). At present, the endemic form of VL disease has been proven in 5 provinces of Iran including Ardabil, East Azarbaijan, Fars, Bushehr and Qom; although sporadic cases are reported from other provinces of the country as well (9). The first report of the disease in Iran was in 1949 after which year at least four provinces had the endemic foci. This disease was reported in Ardabil, Fars, East Azerbaijan and Bushehr provinces (10). Ardabil province had 25-40% of the total number of patients with VL in the whole country and hence is regarded as one of the major focuses of this disease (11). One of the most important areas with regard to the occurrence of Kala azar otherwise VL in Ardabil is Meshkinshahr County. More than 66 percent of reported cases of disease were from Meshkin Shahr (12). The prevalence and distribution of most diseases, including visceral leishmaniasis, are also affected by ecological factors in addition to economic, social and cultural issues. Among the ecological factors affecting the prevalence of this disease, climatic factors are considered as the critical ones (13, 14). Numerous studies have shown the impact and correlation of ecological factors, including the climatic factors with all types of leishmaniasis and their vectors (15-18).

One of these studies found a significantly inverse correlation between climate factors such as relative humidity and leishmaniasis (16). Furthermore, the effect of temperature and humidity on the growth and survival of sand flies has been observed in leishmaniasis vectors (17). In addition, the impact of ponds and rivers in maintaining soil moisture and the feeding of sand flies has been considered in some parts of the Bihar state of India (18). According to the reports provided by Meshkinshahr health center, there has been a higher incidence of VL disease in the region, which has led to the death of children under the age of 10 years old. Therefore, this study aimed at determining the relationship between some of the factors of climate (temperature, rainfall, sunny and snowy days and frost) and the incidence of VL disease in Meshkinshahr County of Ardabil province, Iran.

2- MATERIALS AND METHODS

2-1. Design and population

Ardabil province, located in the North West of Iran , bordered by the Republic of Azerbaijan, the provinces of East Azerbaijan, Zanjan, and Gilan, has an area of approximately 18011 km² (**Figure.1**). This study was performed from April 2001 to September 2017 in Meshkinshahr County of Ardabil province (38.2514°N 48.2973°E, with the elevation of almost 1341 meters above sea level) (**Figure.1**). Meshkinshahr is located in the central part of the province with a population of 171,000. It has 4 districts, Central, Arshaq, Moradlou and East Meshkin. It has a mountainous climate and is located on the slopes of mount Sabalan. The average annual minimum and maximum temperature is -4.6°c and 30°c in January and July, respectively. Total annual rainfall is about 361.2 mm. The relative humidity in the region is about 73% and 48% in December and June, respectively (19).

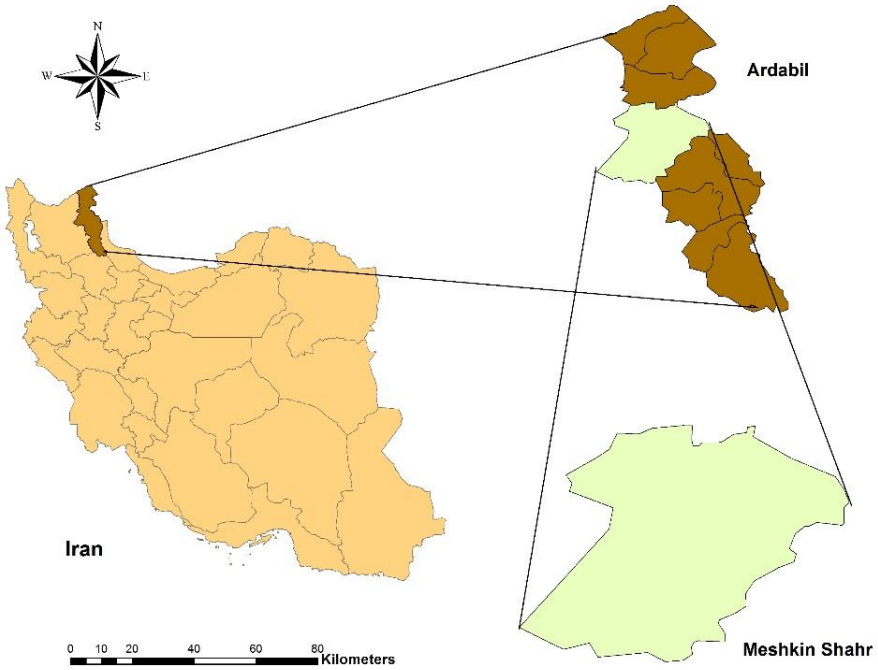

Fig.1: The study area in Ardabil province, Northwest of Iran.

2-2. Methods

In the present study, climatological data such as temperature, rainfall, the number of sunny and snowy days from April 2001 to September 2017 were obtained from the synoptic meteorological office of Meshkinshahr. In addition, all data about Kala azar patients in Meshkinshahr, the endemic focus of VL, was collected during this period, including complete data of patients diagnosed and treated by doctors in hospitals and health centers. It should be mentioned that the history of these patients had been officially reported to the management office of the Ministry of Health. Patient demographic information along with other specifications, including place of residence, travel history, disease symptoms, contact with reservoirs, examination results and treatment outcomes from patient records and individual examination forms were recorded and extracted from medical record files of patients.

2-3. Ethical consideration

At first, the coordination and permission letter was taken from department of disease prevention and control in Ardabil provincial Health Center. It should be mentioned that before the start of the study, the target group was briefed about the objectives of the study and ensured of the confidentiality of their personal information.

2-4. Inclusion criteria

The inclusion criteria were being a permanent resident in urban or rural districts of Meshkinshahr in Ardabil Province, Iran.

2-5. Exclusion criteria

The exclusion criteria were being non-Iranian and not living permanently in the study area.

2-6. Data Analyses

Statistical analysis was performed using SPSS version 23.0 software. Pearson correlation coefficient test was used for data analysis at the significance level of $P>0.05$. GIS3.2 software was used to draw up the map.

3-RESULTS

A total of 226 cases of VL (58.5% males and 41.5% females) were reported in Meshkinshahr County during the study period, namely from 2001 to 2017. Most VL cases (21%) occurred in 2001 and the lowest number of cases (0.5%) were reported in 2013 (**Table.1**).

Regarding the age group, 99.5% of patients were under 10, of whom 86% were under 4. 81.5% of cases were residents in rural areas (**Figure.2**). VL cases had been distributed across 35 regions of Meshkinshahr. Twelve percent of patients were in the Eastern Meshkin, Moradlou and Arshaq and 88% were in the central district of the county. Regarding the seasonal distribution of VL disease, it was shown that the highest rate of reported cases of infection, i.e. 80 cases (35.40%) occurred in winter, 56 cases (24.78%) in spring, 49 cases (21.68%) in autumn and 41 cases (18.14%) in summer. The results of the direct anti-globulin test (DAT test) also showed that 27% of the patients with a DAT index of 1/3,200 were treated and 7% were diagnosed and treated who had a DAT index of 1 /2,560.

During the last 15 years, the average annual rainfall in Meshkinshahr was 392 mm, with the average monthly temperature being 11 ° C (absolute minimum of - 8 and absolute maximum of 38.5 degrees). According to the results of this study, the highest number of VL disease occurred in April, when the average monthly rainfall was 44 mm with the mean temperature of 9 ° C and the lowest was in October, with an average monthly rainfall of 30 mm and a mean monthly temperature of 15 ° C. These changes indicate that the average annual temperature increased by 1.5 ° C annually and the average annual rainfall increased by 1 mL (**Figure.3**).

The highest prevalence of VL disease was reported to be in February and March (**Figure.4**). The results of single-variable linear regression analysis for the relationship between mean annual temperature and mean annual rainfall and incidence of VL showed that there was a significantly indirect relationship, that is the incidence of VL disease decreased with an increase of temperature and the number of sunny days ($P<0.05$) (**Table.2**). Snowy days, rainfall and wind speed did not have a significant relationship with an increase or decrease of disease ($P>0.05$).

Table-1: The annual data of visceral leishmaniasis cases and climatic factors in Northwest of Iran.

Year	Annual of rain fall	Annul of temperature	Number of VL
2001	27	11	43
2002	25.5	10.5	42
2003	30.1	90.6	27
2004	43.3	10.6	20
2005	33.4	10.5	12
2006	22.3	10.9	11
2007	34.7	10	11
2008	24.4	10.2	11
2009	28.9	10.5	8
2010	35.6	12.8	4
2011	45.2	9.6	6
2012	41.3	11.6	4
2013	29.9	11.8	1
2014	27.8	12.2	2
2015	28	12.5	3
2016	29.5	13.2	14
2017	24	13.7	7

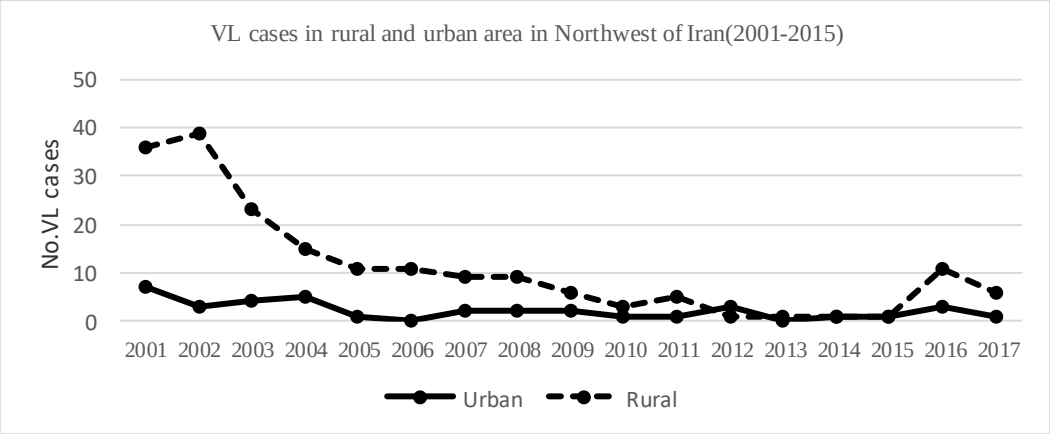

Fig.2: The comparison of Visceral leishmaniasis cases in rural and urban areas in Northwest of Iran (2001-2017).

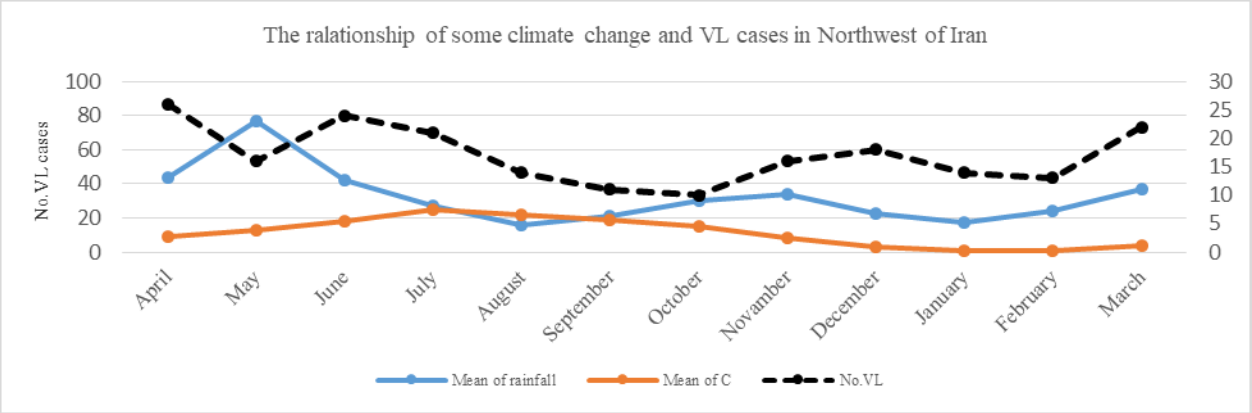

Fig.3: The relationship between VL cases and temperature and rainfall in Northwest of Iran (2001-2017).

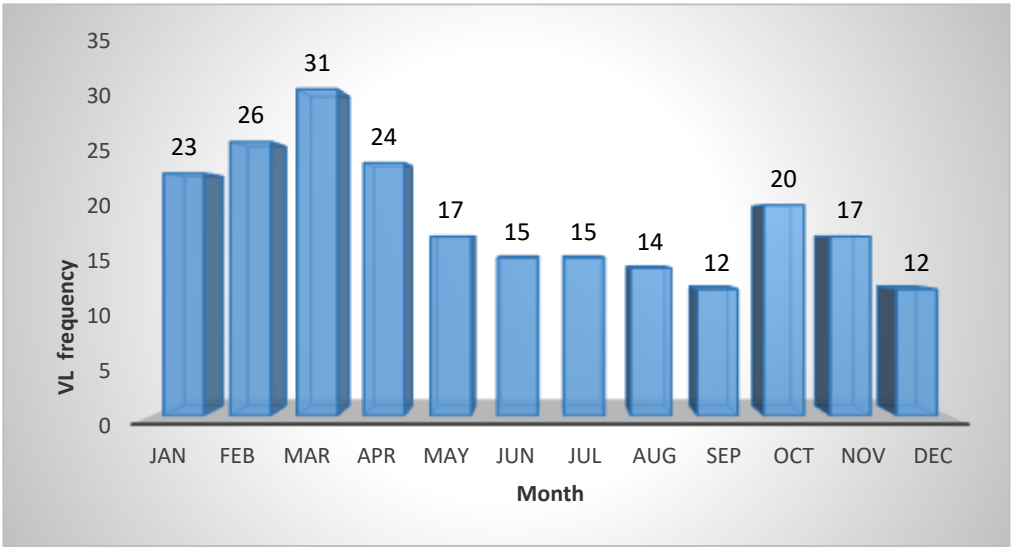

Fig.4: Cases of Visceral leishmaniosis registered monthly in Northwest of Iran (2001-2017).

Table-2: The correlation matrix of temperature and rainfall by annual VL in Meshkinshahr, Ardabil province (2001-2017).

Annual VL	Annual temperature	Annual rain fall	Number snowy days	Number of sunny days
Correlation Coefficient	-0.619	-0.827	-0.106	-0.201
Sig. (2-tailed)	.014	0.064	0.468	0.047
Number of years (2001-2017)	17	17	17	17

4- DISCUSSION

In recent years, various studies have been carried out on some aspects of VL disease, including epidemiological features, laboratory diagnostic and therapeutic methods in some parts of Ardabil province (20). Due to the endemic presence of Kala azar in the world, including Iran, and the occurrence of more than 500,000 new cases annually on a global basis, conducting epidemiological studies continuously and identifying the epidemiological factors of this disease, especially in Iran and determining its relationship with different environmental and climatic conditions are deemed essential (21). The current study was an endeavor to examine the various epidemiological factors of the disease and its relation with some climatic variables from 2001 to 2017. It was found that the prevalence of disease in this county is much higher than in other counties in Ardebil province.

Out of 347 cases in the past 15 years in Ardabil province, 60% had been reported in Meshkinshahr, a finding which has been confirmed by previous studies such as Molai et al. (22) Kasiri et al. (23), and Moradi Asl and colleagues. In this study, the incidence of disease in the spring and winter was more than the other seasons, which is consistent with the studies of Tamuk et al. (24), Chobineh et al. (25) and Ebrahimi et al. (26), and which can be due to the incubation period of the disease in Iran, i.e. 8 months after the reception of infected bites of the vectors of the disease (20). The ratio of the male patients to females being 1.45 to 1 might be attributed to the type of clothing worn by the boys, which leaves parts of their bodies naked, and thus making them more vulnerable to VL disease. The results of the study by Mahami et al. (27) in Garmi County of Ardabil province and the study of Mirsmadi et al. (28) in Azarshahr, East Azarbaijan, were also consistent with the results of this study. However, the results of a study in India showed that the incidence of Kala azar before puberty did not show a significant difference between the two genders, but after puberty, it was higher in males than females, due to the significant difference in secretion of sex hormones in the female fetus after puberty (29). The results of this study indicated that more than 86% of cases have occurred in the age group of less than 4 years. Furthermore, in a study in Kerman (30), the cases were under 2 years old, but the results of a study in Turkey found a higher age group, namely from 5 to 10 years (31). In Brazil (32), and Turkey (31), the age of the infected child is estimated to be 4 years. The effects of climatic variables on the incidence of Kala-azar disease have been proven in different parts of the world, with the most important factors being rainfall and temperature (33, 34); however, its impact and relation with various diseases, including malaria and leishmaniasis are different (35).

The natural growth of all species of sand flies is done at temperatures above 18 ° C which is the threshold temperature for their life (6). Accordingly, the temperature of this area is between 18 and 30 ° C from June to September, which is higher than the threshold temperature. The seasonal activity of sand flies is also in the northwest from late May to early October. In this study, a significant correlation was found between the incidence of VL in different years and the average rainfall and annual temperature ($P < 0.05$), but this relationship was indirect. Several studies in India (36, 37), and Brazil (38) have shown significant relationships between the incidence of disease and the temperature and rainfall.

4-1. Limitations of the study

This study was designed based on registered data in health center of Ardabil province, Iran. The inherent nature of

second-hand data makes it difficult to delve deeply into the exact nature of the effect of climatic changes on visceral leishmaniasis in Meshkinshahr County in Ardabil province, Iran. To the best of authors' knowledge, this can be one of the limitations of the current study.

5- CONCLUSION

The study of epidemiological changes of Kala azar and the effects of some climate factors on the incidence of it in different years indicated that the incidence rate has been increasing after several years of decrease in Meshkinshahr, Ardabil province, Iran. These results showed that VL in Meshkinshahr has been re-emerging in recent years.

6- CONFLICT OF INTEREST: None.

7- ACKNOWLEDGMENT

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