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Leishmaniasis transmission vectors analysis using artificial neural networks

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ABSTRACT

Background: Cutaneous leishmaniasis is the most widespread form of parasitic diseases transmitted by sand flies through their bites causing localized skin lesions or nodular lesions and numerous spots on human skin. In the Setif region of Algeria, the disease has become a major concern for public health. This area is at high risk because it is located near the southern foci of leishmaniasis. Factors that promote parasite transmission are multiple and complex to analyze. The purpose is to determine and enumerate the factors that favor the transmission of leishmaniasis. Establish the parasite dynamics as a function of space and time. **Methods**: An artificial neural network is established. The input variables are factors that favor parasite transmission (Seasons, climatic conditions, defy of migratory flow of population and goods). The output variable is the degree of spread of the leshmaniosis. Since input variables are considered complex, uncertain, an artificial neural network demonstrates its ability to solve such complexity. **Result**: After the learning phase of the network from the real data, this creates a function of correspondence between the space of inputs and output. The function is corrected by adjusting the weights of each input until it is optimized.

Conclusion: The established system makes it possible to instantly read the degree of spread of the leshmaniosis from the introduction of the random values at the input with the maximum precision. The proposed system remains extensible to input variables that may have an effect on the output.

Key words: leishmaniasis, phlebotomine vectors, prevalence, artificial neural networks

Introduction

Leishmaniasis is caused by species of parasites of the genus Leishmania and transmitted by vectors Family psychodidae, phlebotomus or lutzomyia genera [1]. Cutaneous leishmaniasis is considered the most common form that causes localized skin lesions, mucocutaneous infections, or nodular lesions in diffuse cutaneous leishmaniasis [2]. Leishmaniasis encompasses four major eco-enzymatic entities: zoonotic and anthropotic viscotic leishmgniasis, zoonotic and anthroponotic cutaneous leishmaniasis. In anthroponotic forms, humans are the only ones affected. The case of zoonotics mainly concern animals as a reservoir [3]. Thus, leishmaniasis that affects men can be considered as cutaneous leishmaniasis, mucosal leishmaniasis, muco-cutaneous leishmaniasis and visceral leishmaniasis [4-7]. To date, studies on leishmaniasis have considered only a limited number of factors, and virtually all of these studies have been done on endemic areas. It is therefore necessary to develop studies that take into account several risk factors, including studies on the clinical aspects of the risk, environmental predictors as well as co-infections and resistance developed to leishmaniasis. This is necessary because its geographical distribution becomes wider and, despite this, it remains neglected as long as it mainly affects the poorest areas [8].

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The factors involved in the spread of leishmaniasis are diverse and complex [9]. Attempts to analyze these factors are limited. Indeed, these factors are poorly understood and imprecise. In this study, artificial neural network model is proposed to analyze these factors. The proposed network Factors favoring the spread of leishmaniasis are considered as input variables. The rate of attainment by leishmaniasis is considered as an output variable. From the real cases, a function connecting the inputs to the output is created. Once the function is optimized, it will be possible to predict the onset of leishmaniasis from the conditions prevailing in a given area.

Factors promoting leishmaniasis

In order to establish strategies for the control of the disease, it is necessary to have preventive monitoring programs. For this, it is necessary to identify the risk factors associated with leishmaniasis [10]. Factors that promote the emergence and spread of leishmaniasis are complex and include environmental factors such as climate, water supply and storage conditions, irrigation patterns, deforestation, population displacements, Socio-economic conditions, cohabitation with animals ... etc. [11].

Climate change

Ecological factors must be taken into account [12]. Social and environmental factors can influence the cycle of the disease such as rapidly developing town planning and the fact that a concentration of the population. This is more evident in the case of migration from rural to urban areas [13]. On the one hand, global warming and precipitation and moisture influence the population size of host vectors and reservoirs. This has a direct effect on the ecological aspect of these. If the climatic conditions are extreme in the opposite where we are experiencing a drought that leads to famine, for example, this leads to migration of populations creating new endemic areas [14]. The effect of climate change is manifested by the parasite's affect in terms of reproduction, proliferation and abundance of puddles and hence the distribution of leishmaniasis [15]. Another effect of climate change is distinguished on its impact on vegetation areas that also have a role in the outbreak of leishmaniasis [16]. In general, deforestation leads to an increase in leishmaniasis [17, 18].

Socio-economic conditions

Socioeconomic conditions play an important role in the transmission of leishmaniasis. A low level of education, insalubrity makes this population more exposed [19]. Rural and poor areas are therefore the most exposed, particularly the period following the harvest season [20]. It is therefore a disease that mainly affects marginalized people [21]. These people live primarily in houses near garbage or sewers or livestock farms [22, 23].

Endemic areas and Traveling

The occurrence of leishmaniasis, particularly in developed countries, is due mainly to the displacement of populations. There usually, this disease is misdiagnosed. This also concerns the transport of goods from endemic countries [24]. These population movements can also affect the movement of populations from rural to urban areas. Generally, once in the city, they live in low socio-economic neighborhoods where hygiene conditions are not met [25]. This explains the high prevalence observed is the population density in an inadequate life with the presence of vectors and reservoirs in their domestic environments [26, 27]. In these densely populated conditions, infected persons play a role in transmission [28].

Gender

A correlation between sex and the incidence of leishmaniasis was observed and there was a difference between men and women [29]. Men have a higher risk than women. This can be explained by the role of hormones in modulating the response to leishmaniasis [30, 31]. Epidemiological surveys have also shown that hormones play a role in other parasitic diseases [32].

Also, this appearance of a much higher prevalence in men than in women may seem logical. The nature of men's work means that they are more exposed to infected vectors than women [33].

Other Factors

It was found that there is an association between the prevalence of leishmaniasis and cohabitation with animals [34].

It has also been reported that coding of genes associated with the immune response to leishmaniasis can be considered as a risk factor [35].

Arificial neural network

Biology has brought a lot of information about the functioning of the brain, neurons ... Mathematicians then tried to reproduce the functioning of the brain by integrating this knowledge in biology into computer programs, and giving them the possibility of 'learn. Artificial neural networks are currently experiencing a variety of applications in the field of science and technology [36]. Artificial neural networks are mathematical models inspired by our understanding of biological nervous systems.

However, artificial neural networks have the dynamics and the ability to read experimental data from the real environment and are therefore able to solve the complex systems of biophysical processes.

Neural networks are systems learning to perform functions of mapping between two spaces, input space and output space. The application of connectionist techniques has made it possible to deal with problems of medical analysis.

In the analysis of factors that favor the spread of leishmaniasis, an artificial neural network system is constructed. These factors are recorded in the region of Setif in Algeria during the year 2016. Usually, this region is characterized by its semi-arid climate, of average socio-economic level and bordering to areas where cutaneous leishmaniasis is reported. Different factors are recorded based on the number of reported cases (Table 1).

Table 1: Factors Promoting the Propagation of Leishmaniasis

L	*T*	*P*	*H*	*A*	*G*	*D*	*M*	*A.A*	*P.D*	*S.D*	*S.M*	*Z*	*B.S*	*T*	*W*	*VT*	*N*
1	1	1	3	1	1	1	1	1	3	1	1	1	1	1	1	1	646
2	1	1	3	1	1	1	1	1	1	1	1	3	1	1	0	1	646
3	1	1	2	1	1	1	0	1	1	2	1	3	1	1	1	1	213
4	1	1	2	2	1	2	1	2	1	2	2	2	1	1	1	2	154
5	1	1	2	2	1	3	0	3	3	2	2	1	1	1	1	3	74
6	2	2	2	2	1	2	1	3	2	3	1	2	1	0	0	3	42
7	2	1	2	2	1	3	0	2	3	3	3	1	2	0	0	2	35
8	3	2	1	2	2	2	1	2	2	2	3	3	2	0	0	3	19
9	2	2	1	2	2	3	1	1	2	3	3	2	2	1	1	4	12
10	3	2	1	3	2	3	1	3	3	3	1	1	2	0	0	5	8
11	3	3	2	3	3	3	1	2	1	3	1	2	3	1	1	6	7
12	3	3	2	3	2	3	1	1	1	3	1	3	3	0	0	6	4

L: Locality; **T**: Temperature; **P**: Precipitation; **H**: Humidity; **A**: Altitude; **G**: Geomorphology; **D**: Density; **M**: Manure; **A.A**: Anthropologic Activity; **P.D**: Population Density; **S.D**: Sandfly Densisty; **S.M**: Soil Moisture; **Z**: Zone; **B.S**: Bioclimatic Sate; **T1**: Trash; **W**: Wadi; **V.T**: Vegetation Type; **N**: Number.

The factors favoring the propagation of leishmaniasis analyzed are: Locality, Temperature, Precipitation, Humidity, Altitude, Geomorphic density, Manure, activity antropo., Population density, Sandfly density, Soil moisture, Zone, Bioclimatic state, Trash, Wadi, Vegetation type. These factors are considered as input variables according to the number of cases recorded as output variable.

Some parameters are codes in (1, 2, 3) expressing their levels. The introduction of these variables to the input of the system together with the number of cases recorded at the output makes it possible to construct an input-output correspondence function.

The learning phase of the network makes it possible to refine the function to arrive at the minimum error. The weights (W) are readjusted at each case. We note that we must not change networks in each case, but rather vary weights which are mathematical coefficients.

After the learning phase of the network, it becomes possible to predict the number of cases according to these variables.

The optimum of the learning is reached at 180 iterations with a best performance 0.77 and a learning rate 0.004 at 160 epoc. A performance of 10^{-7} is achieved with a gradient of 10^{-5} (Figure 1, 2)

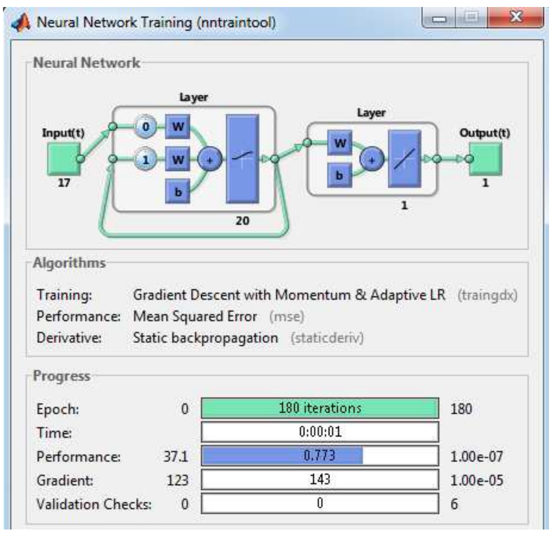

Figure 1. Block diagram of the system

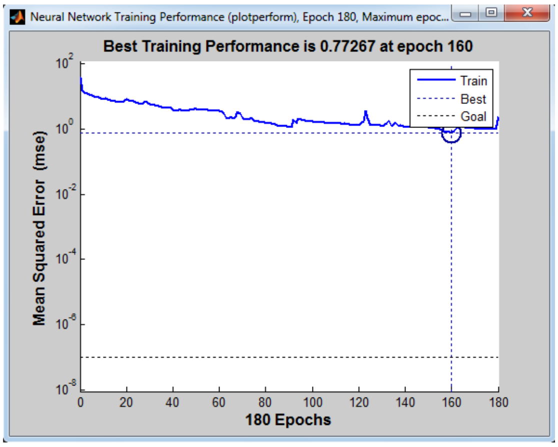

Figure 2. Adjustment of learning function

Conclusion

Since input variables are considered complex, uncertain, an artificial neural network demonstrates its ability to solve such complexity. After the learning phase of the network from the real data, this creates a function of correspondence between the space of inputs and output. The established system makes it possible to instantly read the degree of spread of the leishmaniosis from the introduction of the random values at the input with the maximum precision. The factors involved in this process are multiple and complex and it is impossible to contain all of them. The weight of influence of each factor is poorly known. Some factors are even totally ignored and have their effects. Future studies that will identify other factors or better define their effects, will find in this system a ready platform. The proposed system remains extensible to factors that are not supported in this application.

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