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GEOGRAPHICAL INFORMATION SYSTEMS IN DETERMINATION OF SPATIAL FACTORS IN CUTANEOUS LEISHMANIASIS CASES DISTRIBUTION, IN ADANA, TURKEY

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Abstract

In Turkey, metropolitan municipalities are responsible for the insecticide spraying activities in all districts of the cities. Therefore, insecticide spraying is applied in the center of Adana, in the control of vector arthropods and other pests, especially against the sand flies and mosquitoes.
In this study, we generated cutaneous leishmaniasis (CL) prediction risk maps based on MODIS and NON-MODIS dataset. Firstly, we determined relationship, between the presence of CL patients, human population, insecticide spraying density and several environmental variables [Enhanced Vegetation Index (EVI), Normalized Difference Vegetation Index (NDVI), Digital Elevation Model (DEM), Day Time Mean LST and Night Time Mean LST] obtained from satellite images of randomly selected 103 points were located in the central districts of Adana province, by univariate and binary logistic regression in PASW. (MoH 2016). ARCMAP 10.2. Software was used for geographical adjustments, creating a database and estimating risk models by using several geographical data. The results emphasize that distribution and the presence of the CL cases were found correlated with human population, insecticide, NDVI (LANDSAT), Day time Mean LST and Night Time Mean LST (MODIS).
By using Geographic Information System (GIS) Technologies, the predictions that based on univariate and bivariate binary regression analysis of variables as human population density and insecticide spraying density related to the distribution of CL cases was made. The results were used to produce the prediction maps and the potential distribution areas of the incriminated CL cases with the use of GIS technologies which allowed the identification of the CL risk levels that may provide useful information to guide the control program interventions.

Key words: *Adana, cutaneous, GIS, insecticide, Leishmaniasis*

INTRODUCTION

Leishmaniasis is a vector-borne diseases, is transmitted by bite of vector sand flies abscess to humans prevalence and the publishing of the disease influenced by economic-social and cultural issues, and especially environmental conditions and natural disasters (WHO, 2010; Yazdanpanah and Rostamianpur, 2013). It is space represented in two clinical types: cutaneous and visceral leishmaniasis caused by several space *Leishmania* species in Turkey (Ok et al., 2002; Kavur, 2015).
The study area is located in Turkey at the Adana province. The collected data of human population, insecticide spraying density and CL patient numbers, has significant features as; suitable temperature, humidity values and flora contents for the sustentation of a vector population and the presence of potential *Leishmania* endemic infection areas (Alptekinet al., 1999; Volf et al., 2002; Yaman and Ozbel, 2004; Toprak and Ozer, 2005; Simsek et al., 2007; Svobodova et al., 2009; Tok et al., 2009). These factors has been reported to assist the emergence of CL in the area and a total of 1980 CL patients were diagnosed in 2008 and 2015 in Adana, respectively (MMA, 2015; MoH, 2016). The prevalence and development of leishmaniasis are largely dependent on environmental factors and natural conditions. In addition to the economic, social and cultural conditions, prevalence of leishmaniasis is influenced by ecological factors too. Especially, leishmaniasis incidence has a significant correlation with the values of mean of monthly temperature, the maximum temperature, maximum temperature of monthly (Yazdanpanah and Rostamianpur, 2013). Geographic Information System (GIS) is a system developed to capture, store, manipulate, analyse, manage, and present all types of spatial or geographical data that have associated with them (Glass, 2001). Such as,

they constitute a fundamental tool for studying several disease epidemiology. These tools can be employed to locations of patients, and determine the spatiotemporal relationships among the patients and certain features. Integration of data obtain from many sources correctly and efficiently manipulate and represent different data has driven the improvement of software systems. Recent GIS technologies have emphasized methods to analyse the relationship between several geographical and environmental data, with earlier techniques carried out primarily by the drawing maps to indicate the results. Generally, traditional statistical methods were deficient because underlying spatial correlation among the observations infringes one of the key supposition (independence of observations) made for most analyses. This violation typically results in the assumption of more successful statistical significance than is guaranteed (Lawson et al., 1999). In this study, the CL patient number based prediction map is preferred for the validity to provide sufficient data.

In the present study, it is aimed to determine the relationships between MODIS, NON-MODIS factors and CL cases distribution in our randomly selected study areas in Adana, by using GIS tools.

MATERIALS AND METHODS

Adana province is the fourth major city of Turkey. The city is situated in the East Mediterranean region and has a human population of 1.7 million. It's basin is 14,032 km^{2}in area (Figure 1a). In the present study, Adana city center, located south of Seyhan Dam Lake, was our main study area (Figure 1b). The city is surrounded by the mountain range of Taurus. The Adana province has fifteen districts, 828 villages and a great number of rural areas. Adana has a Mediterranean climate and a dry-hot summer subtropical climate. The mean temperature of Adana province between 1950 and 2014 is 17.5°C (max 23.5°C; min 12.1°C).
The annual mean rainfall between 1950 and 2014 is 688.2 mm. (TSMS, 2015).

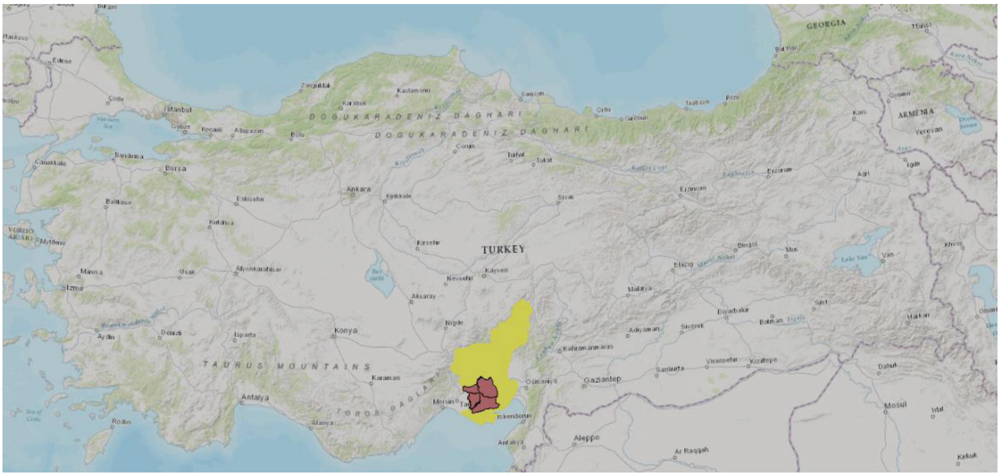

Figure 1. Map of Turkey; Adana province and the study area

In our study, we used dependent (103 CL cases locations) and independent (NON-MODIS and MODIS) variables in statistical analyses. The domestic CL patient's records reported between the years of 2008 and 2015 for the selected 103 points were obtained from MoH, 2016. NON-MODIS data were human population density, the number of the insecticide spraying, NDVI (LANDSAT) and DEM. For the study, human population density data of Adana were obtained from TSI (Turkish Statistical Institute). The insecticide spraying information, including the spraying date and the spraying area were obtained from the Metropolitan Municipality of Adana. Also, NDVI and DEM values are obtained from LANDSAT and SRTM (Shuttle

Radar Topography Mission) respectively. Our MODIS data were EVI, NDVI, Night Time mean LST and Day Time Mean LST.

The statistical analyses were done using PASW statistical package. The results were evaluated in the ARCMAP10.2 software to create the prediction risk maps of CL for the city center of Adana. Firstly a univariate binary regression analysis was undertaken to determine the relationship between presence of CL cases and MODIS and NON-MODIS values. After univariate analysis, data founded significantly ($p < 0.005$) were included the multivariate binary regression analysis for the next step of statistical analysis.

RESULTS AND DISCUSSIONS

The results of the univariate binary regression analysis, presence of CL cases, was found correlated with human population, insecticide applying numbers, NDVI (LANDSAT), Day Time Mean LST and Night Time Mean LST and were shown in Table 1.

Table 1.Univariate Binary Regression Analysis, Between Presence CL cases and MODIS and NON-MODIS Data

NON-MODIS DATA	P values of Presence of CL Cases
Human population	0.000***
Insecticide	0.000***
NDVI (LANDSAT)	0.037*
DEM	0.347
MODIS DATA	**P values of Presence of CL Cases**
EVI	0.90
NDVI	0.276
Day Time Mean LST	0.002*
Night Time Mean LST	0.000***

*** highly significant (< 0.001); ** very significant (< 0.002); * significant (< 0.05)

In Multivariate binary regression analysis, we found all variables as meaningful in terms of presence of CL cases (Table 2). Risk prediction models were created based on result of the multivariate analysis, which calculated for each significant value.

Table 2. Multivariate Binary Regression Analysis, Between Presence CL cases and MODIS and NON-MODIS Data

NON-MODIS DATA	P values of Presence of CL Cases
Human population	0.000
Insecticide	0.000
NDVI (LANDSAT)	0.002
MODIS DATA	**P values of Presence of CL Cases**
Day Time Mean LST	0.000
Night Time Mean LST	0.000

*** highly significant (< 0.001); ** very significant (< 0.002); * significant (< 0.05)

In the study, prediction risk maps, related to presence of CL cases in randomly selected areas, were considered as the MODIS and NON-MODIS variables. After statistical and geographical analyses, the CL risk level found high where the NDVI, temperature, insecticide density and human population values were high.

Recent advances in GIS technologies have provided priceless tools to scientists for analyzing the epidemiology and possible increment of the vector-born diseases (Curran et al., 2000). Many parameters affect the incidence of CL. According to our statistical analysis, we identified that the disease risk or incidence is more closely correlated with the number of the insecticide spraying rather than the human population density (Ozbel et al. 2011; Olgen et al., 2012; Chu et al., 2013).

GIS technologies can be used to reduce the cost of insecticide spraying for the control of vector disease such as malaria and leishmaniasis in many countries (Chang et al., 2009).

In the study, we investigated that environmental and non-environmental parameters are important for the successful control of the CL in Adana province. The distribution and incidence of CL are influenced by urbanization, human population, the insecticide applied locations and environmental factors (Ozbel et al., 2011; Chu et al., 2013). As a result, we determined three environmental (NDVI, Day time LST and Night time LST), two non-environmental (insecticide applying number and human population) indicators in terms of multivariate binary regression analysis.

Risk prediction maps of insecticide and human population (Non environmental) are emphasized that north western part of the city center of Adana has more risk of CL than other parts of the city. It is determined that the CL cases locations are clustered in the highly risky areas (Figure 2). In addition, the high-level risk group in the study area was determined according to the human population and insecticide applying density prediction maps (48.43%).

The high level risk group is followed by moderate (32.28%) and low-level risk groups (19.28%) respectively.

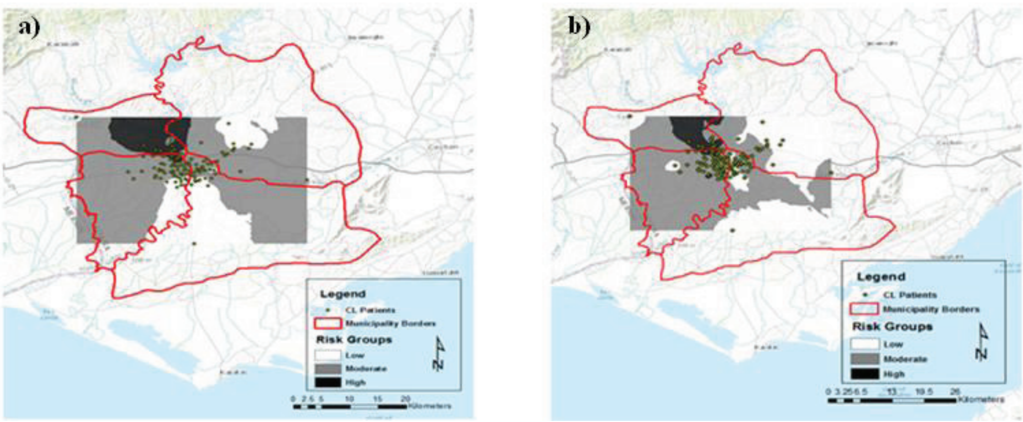

Figure 2. CL Risk maps related to non-environmental factors a) insecticide b) human population

NDVI, day time LST and night time LST (environmental) risk prediction maps also support the non-environmental prediction maps results that showed the north western part of the Adana as highly endemic in terms of CL (Figure 3).

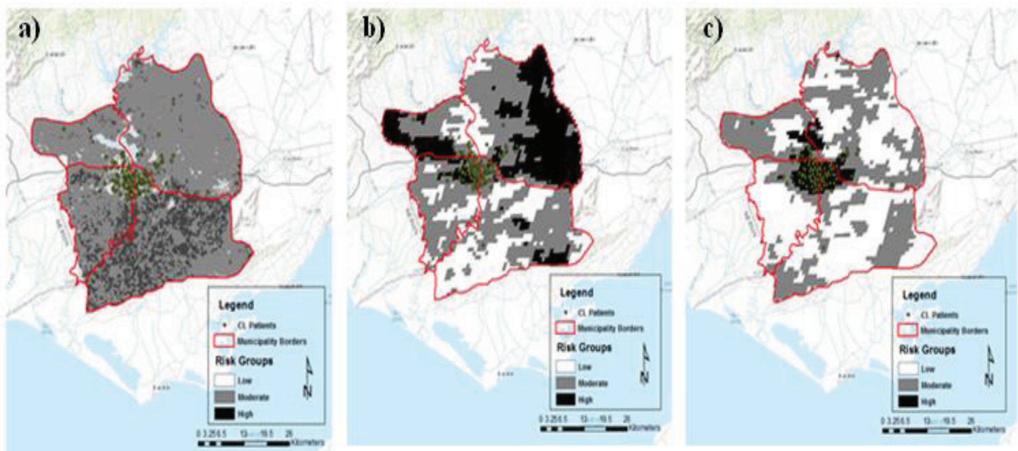

Figure 3. CL Risk map related to environmental factors a) NDVI b) day time LST c) night time LST

The most accurate predictions are provided by day time LST and night time LST risk prediction maps due to land studies in Adana. The high and moderate-level risk groups in the study area were determined according to the daytime LST risk prediction map (96.12%). These risk groups are followed by low-level risk group (3.88%) respectively.

The high and moderate-level risk groups in the study area were determined according to the

night time LST risk prediction map (98.06%). These risk groups are followed by low-level risk group (3.88%) respectively.
For control of vector arthropodes population, both areas must be more spraying than before. The patients number of diseases, human population and insecticide spraying density, however, clearly show that the main hotspot and several additional areas (Chu et al., 2013).

CONCLUSIONS

In conclusion, these prediction maps showed that the potential risk area for CL in terms of the five parameters.
Insecticide resistance could be a major problem if the municipality did not take a measure in several points in Adana.
In the near future leishmaniasis cases number will be increased in the low density insecticide spraying areas. Besides the insecticide applications and human populations, environmental factors, are very important in terms of CL cases distribution.

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