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Role of environmental, climatic risk factors and livestock animals on the occurrence of cutaneous leishmaniasis in newly emerging focus in Iran

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ABSTRACT

Introduction: Occurrence of leishmaniasis is affected by various biological and environmental factors. Kohgiluye and Boyerahmad (K–B) province is an emerging focus of cutaneous leishmaniasis (CL) in Southwest Iran.
Subjects and methods: To elucidate some angles of occurrence of CL in this province, climatic and environmental factors and close proximity to livestock were studied by univariate and two multivariate logistic regression models. The dwelling addresses of 275 CL patients were obtained from Health Centers records for a 5 years period. The effect of mean annual temperature, minimum mean annual temperature, maximum mean annual temperature, mean annual rainfall, slope, elevation, land covers and close proximity to cattle and sheep/goat sheds on the occurrence of CL were analysed using geographical information systems (GIS) approach.
Results: CL occurred in all counties with the most cases in Northwest, West and South semi-arid and warm regions. Land cover, slope, elevation and close proximity to cattle sheds, were the most effective factors. Urban, dry farm and thin rangeland were found as the most important land covers. Slope and elevation decreased the probability of disease. Close proximity to cattle sheds notably increased the chance of CL. The importance of other factors such as rainfall, temperature and close proximity to sheep/goat sheds only were shown when their effects were evaluated independently from other factors. So regions with urban, dry farm and thin rangeland covers with lower slope and altitude where in close proximity of cattle sheds seems to be potentially most high risk areas.
Conclusion: Distribution of CL cases is influenced by combination of environmental, ecological factors and close proximity to livestock sheds but control programs should be focused on cities and villages in the above-mentioned most high risk regions.

Introduction

Leishmaniasis is a major and growing health problem in many countries around the world where natural and man-made environmental risk factors are increasing. Cutaneous leishmaniasis (CL) is the most prevalent form of disease and approximately 700,000 to 1,200,000 new CL cases were reported annually. CL is known as a neglected disease due to low number of fatality cases but it can lead to disfiguring and disabling scars and subsequent notable social and public health problems [1,2]. Distribution and landscape of disease

Abbreviations: CL, cutaneous leishmaniasis; K–B, Kohgiluye and Boyerahmad province; GIS, geospatial information systems; RS, remote sensing; ACL, anthroponotic cutaneous leishmaniasis; ZCL, zoonotic cutaneous leishmaniasis; MAR, mean annual rainfall; MAT, mean annual temperature; MaxMAT, maximum annual temperature; MinMAT, minimum annual temperature; DEM, digital elevation model.

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has been markedly influenced by climatic and environmental conditions, as well as demographic and human activity factors due to dynamic nature of leishmaniasis as a vector-borne disease [3]. Geographical information systems (GIS) and remote sensing (RS) have been found valuable tools to help researchers determine the effectiveness of these probable risk factors on distribution of disease. Ecological modelings using GIS and RS have been notably considered for the vector borne diseases in recent 25 years [4]. Of course the increase of availability of climatic and geological data in digital format facilitates performance of GIS based studies. GIS can integrate the various environmental, ecological and every georeferenced characteristics and information seamlessly to evaluate their effects on the occurrence and epidemiology of diseases [5]. These tools also have been applied to stratify different land covers on the ground and identify high risk land covers for the studied disease. Furthermore GIS can provide useful information for policy makers for proper resource allocation and implementation of control measures [2].

In spite of increasing number of GIS based studies on the leishmaniasis in some developing and developed countries, only few studies have been conducted in Iran [6–8]. Iran is one of ten countries where most of cutaneous leishmaniasis (CL) cases (up to 75%) have occurred. CL is also the most important vector-borne disease in Iran and is endemic in more than half of the 31 provinces of Iran [9] where more than 24,000 cases have occurred annually [2]. *Leishmania major* and *Leishmania tropica* are the main causative agents of zoonotic cutaneous leishmaniasis (ZCL) and anthroponotic cutaneous leishmaniasis (ACL) in Iran, respectively. ZCL was endemic in Northeastern, Central, Western and Southwestern provinces of country with some foci in Southeastern regions [10–13]. While ACL is confined in some urban regions in Shiraz (Southwest), Tehran (Central), Mashhad (Northeast), Kerman (Southeast) and some smaller cities and surrounding rural regions including Birjand and Bam in East and Southeast regions of Iran and with extension to neighboring districts in Heart Afghanistan [14–19]. Human is the main reservoir host of ACL and sandfly *Phlebotomus sergenti* is known as the main vector in Iran while *Phlebotomus papatasi* is the main vector and *Rhombomys opimus*, *Tatera indica*, *Meriones hurrianae*, and *Meriones libycus* gerbils are the main reservoir of ZCL in this country [11,20–22].

K–B province in Southwest Iran is surrounded by endemic foci of ZCL including Fars province in Southeast and East, Bushehr province in South, Khuzestan province in West and Isfahan province in Northeast regions. This province was not the known as the focus of CL but notable numbers of CL cases were identified in it in recent years. This study was conducted to elucidate the distribution pattern of CL cases in this emerging focus and evaluate the effect of environmental, climatic risk factors and livestock on the occurrence of disease in the studied regions.

Materials and methods

Study areas

K–B province is located between latitude 30°9′ and 31°32′N and longitude 49°57′ and 50°42′ in Southwest Iran and consisted of 8 counties and surrounded by the provinces are shown in Fig. 1. The isothermal and isohydral maps showed various weathers in the province. East and Northeast and North regions showed cold and wet weather but most West, South and some Central areas were considered as warm and semi-arid regions. The elevation decreases from northeast to southwest and in a range from 4283 m in Dena Mountains summits with the second highest summit in Iran to 115 m in the plains. Most North and Northeast areas are covered by Zagros Mountains chain. Although most of people dwell in villages and some cities but nomads are the main population in this province and most of rural and urban populations have originated from nomad tribes. Nomads are populations belonging to different tribes who spend their life herding. They annually travel from their summer quarters (Yailaq) to winter quarters (Qishlag) and vicev-ersa. Herding is the main job among people. Regarding Veterinary Bureau consensus, the number of small livestock (sheep/goat) and cattle were 1,543,300 and 67,344 respectively. A notable number of people are also usually involved in agriculture and gardening in this province.

Data collection

Regarding Health ministry control program, CL was carefully recorded by Iranian Health Centers even in remote regions. CL cases were diagnosed by resident physicians based on the epidemiological, clinical and historical evidences and result of microscopic examination. Residential addresses of all patients diagnosed from 2009 to 2013 including 278 cases were obtained from K–B Province Health Center database. Three cases were excluded due to incomplete address. For confirmation of validity of residential addresses, we called the phone number recorded with the residential address of each patient. Some nomads gave the their address of nearest villages to their residential places which accepted due to short distance between them that could not influence on the environmental and climatic factors.

Geospatial data

Regarding latitude and longitude of cities and villages from which CL cases have been reported, patients' residences were located on the shape file map of province consisted of counties, rural districts, cities and villages. Statistical analysis was based on the presence or absence of patient in each point.

Minimum, maximum and mean annual temperatures (centigrade unit) from all six synoptic stations (stations which collected meteorological data at 6 or 3 h periods in day and night) including; Imamzadeh Jafar, Dehdasht, Likak, Dogonbadan, Sisakht and Yasuj cities were obtained from K–B province Weather Bureau. To qualify the isothermal map, temperature data also were retrieved from some synoptic stations including Lordegan, Brojen, Izeh and Ramhormoz in neighbor joining provinces. Annual rainfall data from 45 rainfall assessment stations were obtained also from K–B province Weather Bureau.

Mean annual rainfall (MAR), mean annual temperature (MAT), maximum annual temperature (MaxMAT) and minimum annual temperature (MinMAT) were calculated based on the annual temperature and annual rainfall of the studied years, respectively. All meteorological raster layers were developed by tension based *spline* interpolation method with a resolution grid of 2 × 2 km for K–B province after checking various models of interpolation.

Digital elevation model raster layer and land cover vector layer (including features covers the province surface) were retrieved from the province department of agricultural affairs. Slope raster layer was generated based on DEM (digital elevation model) map by calculating the maximum rate of change in value between each cell and its neighbors by using spatial analyst tool.

Livestock shed hazard map

Regarding extensive animal husbandry and as a common job among K–B residents and role of organic soils as possible breeding places of sandflies, the hazard maps were produced by unifying 5 km buffers around livestock sheds. The shape file layer of livestock sheds was retrieved from K–B province Veterinary Bureau. The hazard maps were separately designed for livestock shed with

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