Spatio-temporal analysis of cutaneous leishmaniasis using geographic information system among Iranian Army Units and its comparison with the general population of Iran during 2005–2014

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Abstract To investigate the time trend and distribution of cutaneous leishmaniasis in Iranian Army Units (IAUs) and general population (GP). with using census, Data on CL incidence in IAUs (from AJA University of Medical Sciences) and GP (from Ministry of Health) during 2005–2014 were extracted and entered into the GIS software. Cochran–Armitage test, choropleth map, hot-spot analysis and high/low clustering analysis were used to determine time trend, distribution of disease, hot-spots, and possible abnormal clustering, respectively. The number of infected individuals in IAUs and GP were 6533 and 153,499 respectively (with incidence rates of 143.68 per 100,000 and 25.86 per 100,000, respectively). Time trend analysis revealed the departure from linear trend for the incidence in IAUs ($p < 0.001$), but no such time trend was found in GP. According to choropleth maps; in IAUs, Khuzestan from southwest, Esfahan from central and Kermanshah from west parts of Iran and among GP; Fars, Yazd, and Kerman in southern-east of Iran showed a high incidence rates. In IAUs, Esfahan and Khuzestan provinces was hot-spots of CL

($p < 0.05$), but in GP, provinces like Fars and Khorasan-shomali was hot-spots ($p < 0.05$). No clustering pattern of disease was observed in either study populations. Observed spatiotemporal variability in CL among IAUs and GP warrants proper health programs particularly to Khuzestan and Esfahan in IAUs and Fars and Khorasan-shomali in GP are highly recommended.

Keywords Cutaneous leishmaniasis · Army units · Geographic information system · Spatio-temporal analysis

Introduction

Cutaneous leishmaniasis (CL) is one of the most common forms of leishmaniasis, transmitted through a variety of sand fly species (Reithinger et al. 2007). Global researchers have reported a morbidity rate of more than 1,000,000 over the last 5 years (Leishmaniasis and facts 2014), with 300,000 new cases reported annually (Desjeux 1996). CL has been reported at least in 70 countries, with 90% of them are concentrated within Afghanistan, Algeria, Brazil, Pakistan, Peru, Saudi Arabia, and Syria (Desjeux 2004a, b; Aflatoonian et al. 2016). Surveillance system data shows a growing incidence rate of CL worldwide, indicating the importance of this disease (Reithinger et al. 2007).

In Iran, CL endemically occurs in two forms included Zoonotic-CL (ZCL) and Anthroponotic-CL (ACL) (Manual Leishmaniasis 2016; Sharifi et al. 2011). Studies have shown that health system was challenged by huge number of cases, such as in 2009 approximately 26,000 cases of CL were reported (Shirzadi et al. 2015; Gholamrezaei et al. 2016; Heydarpour et al. 2016; Holakouie-Naieni et al. 2017).

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CL represents a complicated ecologic cycle and various factors have been suggested to affect the incidence of disease such as; geographical location and climate. CL is frequently found in tropical areas (Gage et al. 2008; Chelbi et al. 2009; Salehi-Moghadam et al. 2015; Barati et al. 2016). One of the useful tools capable of evaluating the effect of these spatial factors is geographic information system (GIS). This system not only provides descriptive maps of high risk areas and the incidence of probable cumulative disease trend (Hot Spot Analysis 2016; Asgari 2011), but also predicts the distribution of the disease. (Inverse Distance Weighted 2016).

Despite the presence of leishmaniasis in the majority of provinces of Iran, with a high percentage in countryside (Mirzazadeh et al. 2009; Holakouie-Naieni et al. 2017), army units are one of the most prevalent places that experiences the leishmaniasis due to the distinct spatial status (Weina et al. 2004). Various studies aimed to investigate the status of CL in general population (GP) utilizing GIS (Mirzazadeh et al. 2009; Holakouie-Naieni et al. 2017). However, there are few studies that tried to employ this method to investigate the population of Iranian Army Units (IAUs). Using descriptive maps of CL incidence in IAUs (Salehi-Moghadam et al. 2015) article reported a high incidence among the army units located in Khozestan and Esfahan. Within GP, a study by Holakouie-Naieni et al. showed changing high risk foci of CL. Using hot-spot analysis, study revealed that over the span of three decades high risk areas have been changed from south-western to northeastern parts of Iran. However, over the last decade, the main foci of CL are reported from central provinces such as; Fars, Kerman, and Yazd.

In order to identify high risk areas affected by CL within GP and IAUs, this study aimed to provide spatio-temporal modeling for CL from 2005 to 2014 and to compare such models between IAUs and GP.

Methods

The study area

Iran is a country in the Middle-East with the area of 1,648,195 km². It is the 16th largest country in the world and has a population of over 80 million (2016). Iran has a variety of environmental conditions in terms of length and breadth of geography, topographic diversity, and a range of altitude up to 5671 m above sea level. Iran's climate varies from arid to subtropical so that the mean rainfall varies 100–2000 mm and temperature ranges from 0 to 50 °C (Mostafavi et al. 2013). Iran has border with Armenia, Turkmenistan, and Azerbaijan in the north, Afghanistan and Pakistan in the East, Persian Gulf and Gulf of Oman in

the south, Iraq in the east; and Turkey in the northwest. Iran is currently divided into 31 provinces (Holakouie-Naieni et al. 2017).

Study design, data collection and joining tables to GIS

This ecological study was conducted utilizing data on CL disease among IAUs and GP between 2005 and 2014. Ministry of Health and Medical Education provided data on the incidence of CL in the GP, while data for IAUs was taken from the health deputy of AJA Military University of Medical Sciences. Data was then transferred to MS Excel. Latest edition of electronic map was provided and to create one database, information table from map was merged with the data set of incidence rate by using common identifier within both data sets.

Time trend analysis

Cochran–Armitage test for linear trend was used to analyze the possible trends of disease incidence in IAUs and GP over the study period. This test assesses either decrease or increase in the rate of disease in different times and also is used to determine the meaningful changes in the process of disease. For time trend analysis we used Stata11 (Stata-Corp, College Station, TX, USA) (Nam 1987).

Choropleth map

A choropleth map is a tool that uses a range of colors to show variable changes in the layers of polygons produced at the provincial level. For the reason of better detection of any changes in the distribution of CL, a series of choropleth maps for CL in the time frame of 2 years were created.

Hot spot analysis

Disease hotspots were identified by using the Getis-OrdGi* statistic (Hot-Spot Analysis 2016; Asgari 2011). The Hot Spot Analysis tool calculates the Getis-OrdGi* statistic (Eq. 1) for each province in a dataset. The resultant Gi score tells us how provinces with either high or low incidences spatially cluster. This tool works by analyzing each province within the context of neighboring provinces. A province with a high incidence of CL was considered to be a statistically significant Hot Spot especially when being surrounded by provinces with a high incidence rate of CL. The value belonged to a particular province was compared proportionally to that of the rest provinces; if the local value is much different than the expected local sum and difference is too large to be the result of random chance, a

statistically significant G_i score would be obtained. To the contrary, a cold spot province is the one in which a low incidence of CL is detected and also is surrounded by provinces with low incidence. For hot-spot analysis, spatial weight calculated by Fixed Distance Band method. In this method, each province is analyzed within the context of neighboring provinces. Neighboring provinces inside the specified critical distance receive a weight of one and exert influence on computations for the index province. Provinces outside the critical distance receive a weight of zero and have no influence on an index province's computations. To determine the distance of neighboring zone around the index province, we used Euclidean Distance method that calculates distance between two polygon's (i.e. province) center. In other word, it is minimum distance between centers of two polygons. Center of polygons were determined by the centroid method. For weighting, no standardization of spatial weights was applied.

$$G_i = \frac{\sum_{j=1}^n w_{ij} x_j - \bar{x} \sum_{j=1}^n w_{ij}}{S \sqrt{\frac{n \sum_{j=1}^n w_{ij}^2 - \left(\sum_{j=1}^n w_{ij} \right)^2}{n-1}}} \quad (1)$$

Equation 1: Getis-Ord G_i^* (G_i^* Statistics)—where X_j is the incidence of CL for province j , w_{ij} is the spatial weight between province i and j , n is equal to the total number of provinces.

High/low clustering analysis

High/low clustering analysis was also used for detecting the concentration of high or low Incidence of CL for the chosen study area. To achieve this goal, we used General statistics (G statistics), a method developed by Getis and Ord capable of measuring how the high or low incidence areas are distributed. A positive or negative z-score for $G(d)$ indicates spatial clustering of high or low Incidence, respectively (Eq. 2) (Hot Spot Analysis 2016; Holakouie-Naieni et al. 2017).

$$G = \frac{\sum_{i=1}^N \sum_{j=1}^N w_{ij} x_i x_j}{\sum_{i=1}^N \sum_{j=1}^N x_i x_j}, \quad \forall_j \neq i \quad (2)$$

Equation 2: G statistics—where x_i and x_j , respectively, are the Incidence of CL in the i th and j th Provinces; w_{ij} is the spatial weight between the Province i and j ; N is the total Incidence of CL; and S_0 is the aggregate of all spatial weights.

Ethical consideration

The Ethics Committee of AJA Military University of Medical sciences approved the study protocol, which was conducted in accord with the tenets of the Helsinki Declaration.

Results

The total number of infected cases between 2005 and 2014 in IAUs and GP were 6,533 and 153,499 respectively. An incidence average of 143.68 and 25.86 per 100,000 was estimated in IAUs and GP, respectively. Figure 1 demonstrates the incidence of CL in each province's IAUs and GP. As shown in this figure, Esfahan, Khozestan, and Kermanshah were provinces with the highest incidence of CL among all IAUs. On the other hand, the GP of Fars, Ilam, and Kerman showed the highest incidence rate. It is also worth noticing that some provinces like Yazd and Khorasan-Razavi seem to have higher incidence rate with GP as compared to IAUs. Overall speaking, the IAUs have higher rate of incidence of CL.

Time trend

As shown in Fig. 2, the time trend in IAUs shows major fluctuations. The lowest and highest levels of incidence were reported in 2010 and 2011, respectively. In addition to this visual inspection, by Cochran–Armitage analysis,

Fig. 1 Mean of CL Incidence during 2005–2014 in each province partition by general population (GP) and Iranian Army Units (IAUs)

the incidence rate of CL does not follow a linear trend ($p < 0.001$). Assessment on GP showed the highest and lowest rate of incidence during 2006 and 2013, respectively. No time trend was identified for the disease incidence in GP as well.

Fig. 2 Mean of CL incidence based on year in general population (GP) and Iranian Army Units (IAUs) during 2005–2014

Spatial modeling

The choropleth 2-year maps from 2005 to 2014 are separately demonstrated for IAUs and GP in Figs. 3 and 4, respectively. Over the study period, Khuzestan, Esfahan, Kermanshah, Zanjan, Bushehr, Sistan-Baluchestan classified as provinces with a high incidence in IAUs (>200 per 100,000). Whereas within the GP; Fars, Kerman, and Yazd introduced as high incidence provinces. Comparing the choropleth maps of IAUs and GP, it is illustrated that the IAUs have higher incidence. Furthermore, we noticed a different pattern of incidence between these populations.

Figures 5 and 6 exhibits the hot-spot maps of CL in IAUs and GP. Results in IAUs revealed that Khuzestan bore remarkably higher incidence rate in 2005–2006, 2009–2010, and 2011–2012, when compared to the overall average and considered as a hot-spot ($p < 0.05$). This analysis also reports a significantly higher incidence rate in

Fig. 3 Choropleth maps of CL incidence in Iranian Army Units (IAUs) during 2005–2014

Esfahan in 2011–2012, compared to that of country's average. This finding led us to classify this province as a hot-spot of CL ($p < 0.05$). Hot-spot analysis in IAUs indicates a steady rate of incidence over the last years of study, and that no CL cold-spot province was identified over the entire period of study.

Hot-spot analyses in GP showed the Fars province as a hot-spot in 2005–2006 and 2007–2008, with a tremendously greater incidence of CL in comparison with the country average ($p < 0.05$). Additionally, these analyses suggested the northwest provinces as low-risk areas and considered as cold-spot provinces.

Clustering analysis

In respect to the high/low clustering analysis, conducted in 2-year distinct periods, a normal distribution of data was

observed, whereas no low/high frequency clustering was observed either in IAUs or GP.

Discussion

Regarded as a major global health issue, CL is endemic in southern- and northern-Mediterranean countries (Desjeux 2004a, b; Chelbi et al. 2009). Previously found in Iran, this disease has yielded a notable economical and health damages. Therefore, preventive strategies are of particular interest, especially for IAUs (Mehrabi-Tavana and Esfahani 2005; Salehi-Moghadam et al. 2015) and GP (Holakouie-Naieni et al. 2017). In this study, we used documented data and GIS to provide a spatio-temporal modeling for CL. In addition, the distribution and spatio-temporal changes in Iran's IAUs and GP between 2005 and

Fig. 4 Choropleth maps of CL incidence in general population (GP) during 2005–2014

2014 were analyzed. Furthermore, by comparing these populations, we were able to enhance the CL preventive programs.

The total number of infected people with CL over the study period of 2005–2014 was 6533 among IAUs, significantly lower than that of GP (153,499 cases). However, regarding the fact that the ratio of identified to unidentified cases was 3–5 (Manual Leishmaniasis 2016; Shirzadi 2012), it may be concluded that at least 20,000 IAUs and 450,000 GP cases were infected during these years.

Comparison of the CL incidence in IAUs and GP indicated a higher percentage in IAUs, as over the period of study, the number of infected IAUs members was 143.68 per 100,000, with 25.86 per 100,000 in GP. Therefore, it can be concluded that the incidence of CL in IAUs is higher than that of GP, implying the great burden of disease in army.

Time trend analysis over one decade in IAUs showed a periodical/circulating trend, with 4–5 years periodical decrease and increase. Although at the end of the study period, the incidence rate has increased in IAUs but no such trend was observed in GP. Similar observations were reported by Holakouie-Naieni et al. (2017). Other studies have noted 5–6 years of periods of changing in the incidence trend (Salah et al. 2007). This difference appears to be the result of the distribution of vectors, changes in disease reservoir population, climate, and life style of population in the high risk areas (Shirzadi 2012). On the other hand, the study of the disease time trend in IAUs and GPs showed that in some years, the disease in the IAUs has sharply increased; while in GP, disease has almost monotonic. It seems that the fluctuations in the IAUs are due to climate change and most importantly, entry of susceptible populations to disease foci (Aflatoonian et al. 2016; Sharifi et al. 2011).

Fig. 5 Hot spot maps of CL incidence in Iranian Army Units (IAUs) during 2005–2014

Descriptive maps illustrated a distinct picture of CL pattern, such as Khozestan and Esfahan have higher number of infected IAUs than IAUs of other provinces. Beside these two provinces, IAUs belonged to provinces like Kermanshah, Bushehr, Semnan, Qom, Qazvin, and Zanjan also have higher incidence rate of CL. This pattern was also found in Salehi-Moghadam et al. study conducted on army units (Salehi-Moghadam et al. 2015).

On the other hand, disease distribution in GP showed a different pattern. GP of Fars, Ilam, Kerman, and Yazd were classified as provinces with a high incidence, similar to what Holakouie-Naieni et al. (2017) have reported.

Variation found in the incidence of CL between GP and IAUs can be attributed to flowing three reasons. Firstly, the presence of active foci in mentioned provinces that provide the ideal environmental conditions for vector and reservoir. Some of active foci were present in Mobarakeh and

Barkhoar, Natanz, Kashan, and Ardestan regions of Esfahan province (Yaghoobi-Ershadi et al. 1995; Talari et al. 2006; Parvizi et al. 2010), and Ahwaz, Dezful, and Shush regions of Khuzestan province (Sedaghat and Salahi 2010; Holakouie-Naieni et al. 2017). Secondly, the different lifestyle and environmental status among army staffs. These units often are located outside of cities. Due to the lack of appropriate health facilities, and also specific tropical status, the possibility of reservoir rodent growth and subsequently increase in the population of *Anopheles* will be strengthened. Thirdly, military population often moves for the reason of military missions and training, and very often travels to the tropical areas. Increased risk of morbidity is also attributed to the fact that large military population has meager facilitations and lack of health considerations, resulting in an appropriate environmental situation for both reservoirs (*Rh. opimus* and *M. libycus*)

Fig. 6 Hot spot maps of CL incidence general population (GP) during 2005–2014

and vector (*ph.papatasi*). Lastly, every year, many soldiers are recruited to army units. These soldiers usually come from non-endemic areas. The entry of susceptible people leads to the continuation of the disease transmission cycle.

One of the most important finding of this study achieved by analyzing and comparing the hot-spot maps in both IAUs and GP. These analyses showed diversity in distribution of CL between two studies groups. Indeed, hot-spot analysis classified Khozestan and Esfahan as significant hot-spot provinces. This finding showed a notably higher incidence of CL in IAUs located in these provinces. However, during the later years of study period, the distribution of CL incidence represented a steady rate in IAUs with no hot-spot areas. The importance of mentioned provinces as foci of disease in army units has been reported in other studies as well (Mehrabi-Tavana and Esfahani 2005; Salehi-Moghadam et al. 2015). In contrast, the hot-spot provinces were completely different in GP, Fars, Yazd, and Khorasan-shomali were regarded as hot-spot areas, and study (Holakouie-Naieni et al. 2017) reported similar result. Although it is difficult to precisely interpret these differences, it may be due to the different study populations and most importantly, diverse geographic and lifestyle status.

High/low clustering analysis did not show any CL clustering in GP and IAUs. This finding was similar to study (Holakouie-Naieni et al. 2017), while different finding was reported in other studies (Mollalo et al. 2015; Elnaïem et al. 2003; Sudhakar et al. 2006; Salah et al. 2007; Chelbi et al. 2009; Barbosa et al. 2014). The reason may be due to the level of analysis, as in studies with different result (Elnaïem et al. 2003; Sudhakar et al. 2006; Salah et al. 2007; Chelbi et al. 2009; Barbosa et al. 2014; Mollalo et al. 2015) small areas were considered. This led to the increased number of studied areas (polygons) and subsequently increased possibility of clustering patterns. In our study and other study (Holakouie-Naieni et al. 2017) analysis were conducted for provinces and resulted in decreased number of polygons and the limited power of finding clustering patterns by clustering test.

According to the fact that there are two types of CL, ZCL and ACL, and to the difference in epidemiological feature of these two types, it was better to analyze them separately. The main reason we failed to consider this point has to do with the fact that collected data did not discriminate these kinds of CL from each other.

Conclusion

CL found to be more prevalent among IAUs than GP. In addition, distribution of this disease in IAUs was different from GP. Therefore, for the reason of diverse geographic

and environmental features in army units, specific health strategies need to be adopted for people who work or live in these areas. In addition, urgent and particular management of health, combating the reservoirs, proper waste disposal and inducing infertility in vectors are highly recommended for provinces like Esfahan and Khozestan.

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Authors’ contribution Arasb Dabbagh-Moghaddam and Mehdi Mohebbali: Data gathering, refinement of Data, Data entering. Saeid Safiri and Reza Pakzad: design of study, analysis of data, interpretation of result, Mohammad Barati: analysis of data, writing of manuscript. Arasb Dabbagh-Moghaddam and Mehdi Mohebbali: edit and approve of final manuscript.

Compliance with ethical standards

Conflict of interest None.

References

- Aflatoonian MR, Sharifi I, Aflatoonian B, Shirzadi MR, Gouya MM, Kermanizadeh A (2016) A review of impact of bam earthquake on cutaneous leishmaniasis and status: epidemic of old foci, emergence of new foci and changes in features of the disease. *J Arthropod Borne Dis* 10:271–280
- Asgari A (2011) Analysis of spatial statistics in ArcGIS. Organization of Tehran Municipality Information and Communication Technology, Tehran [In Persian]
- Barati H, Lotfi MH, Mozaffari GA, Barati M, Dehghan HR, Firouze AT (2016) Epidemiological aspects of cutaneous leishmaniasis in Yazd province within 2004–2013. *J Comm Health Res* 5:131–139
- Barbosa DS, Belo VS, Rangel ME, Werneck GL (2014) Spatial analysis for identification of priority areas for surveillance and control in a visceral leishmaniasis endemic area in Brazil. *Acta Trop* 131:56–62
- Chelbi I, Kaabi B, Bejaoui M, Derbali M, Zhioua E (2009) Spatial correlation between *Phlebotomus papatasi* Scopoli (Diptera: Psychodidae) and incidence of zoonotic cutaneous leishmaniasis in Tunisia. *J Med Entomol* 46:400–402
- Desjeux P (1996) Leishmaniasis: public health aspects and control. *Clin Dermatol* 14:417–423
- Desjeux P (2004a) Focus: leishmaniasis. *Nat Rev Micro* 2:692–693
- Desjeux P (2004b) Leishmaniasis: current situation and new perspectives. *Comp Immunol Microbiol Infect Dis* 27:305–318
- Elnaïem DE, Schorscher J, Bendall A, Obsomer V, Osman ME, Mekki AM et al (2003) Risk mapping of visceral leishmaniasis: the role of local variation in rainfall and altitude on the presence and incidence of kala-azar in eastern Sudan. *Am J Trop Med Hyg* 68:10–17
- Gage KL, Burkot TR, Eisen RJ, Hayes EB (2008) Climate and vectorborne diseases. *Am J Prev Med* 35:436–450
- Gholamrezaei M, Mohebbali M, Hanafi-Bojd AA, Sedaghat MM, Shirzadi MR (2016) Ecological Niche modeling of main reservoir hosts of zoonotic cutaneous leishmaniasis in Iran. *Acta Trop* 160:44–52

- Heydarpour F, Sari AA, Mohebbali M, Shirzadi MR, Bokaie S (2016) Incidence and disability-adjusted life years (Daly) attributable to leishmaniasis in Iran, 2013. *Ethiop J Health Sci* 26:381–388
- Holakouie-Naieni K, Mostafavi E, Bolorani AD, Mohebbali M, Pakzad R (2017) Spatial modeling of cutaneous leishmaniasis in Iran from 1983 to 2013. *Acta Trop* 166:67–73
- How Hot Spot Analysis (Getis-Ord Gi*) Works (2016). http://resources.esri.com/help/9.3/arcgisengine/java/gp_toolref/spatial_statistics_tools/how_hot_spot_analysis_colon_getis_ordinal_star_spatial_statistics_works.html. Accessed July 2016
- How Inverse Distance Weighted (IDW) interpolation works (2016). http://resources.arcgis.com/en/help/main/10.2/index.html#/How_IDW_works/009z00000075000000/. Accessed July 2016
- Leishmaniasis and facts (2014) World Health Organization [online]. <http://www.who.int/topics/leishmaniasis/en/>. Accessed July 2016
- Manual for case management of cutaneous leishmaniasis in the WHO Eastern Mediterranean Region. WHO Regional Publications, Eastern Mediterranean Series (2016). http://applications.emro.who.int/dsaf/EMROPUB_2013_EN_1590.pdf. Accessed July 2016
- Mehrabi-Tavana A, Esfahani A (2005) Cutaneous Leishmaniasis in imposed war (Iraq against IR of Iran) during 1980–88. *Ann Mil Health Sci Res* 3:507–511
- Mirzazadeh A, Hajarizadeh B, Mesgarpour B, Golozar A, Holakouie Naieni K (2009) Mapping of cutaneous leishmaniasis in Kerman city from 2002 to 2006 and its environmental risk factors by geographical information system. *Iran J Epidemiol* 4:17–25
- Mollalo A, Alimohammadi A, Shirzadi MR, Malek MR (2015) Geographic information system-based analysis of the spatial and spatio-temporal distribution of zoonotic cutaneous leishmaniasis in Golestan Province, north-east of Iran. *Zoonoses Public Health* 62:18–28
- Mostafavi E, Haghdoust A, Khakifirouz S, Chinikar S (2013) Spatial analysis of Crimean Congo hemorrhagic fever in Iran. *Am J Trop Med Hyg* 89:1135–1141
- Nam J (1987) A simple approximation for calculating sample sizes for detecting linear trend in proportions. *Biometrics* 43:701–705
- Parvizi P, Baghban N, Novin EA, Absavaran A (2010) Detection, identification and molecular typing of *Leishmania major* in *Phlebotomus papatasi* from a focus of zoonotic cutaneous leishmaniasis in central of Iran. *Exp Parasitol* 124:232–237
- Reithinger R, Dujardin JC, Louzir H, Pirmez C, Alexander B, Brooker S (2007) Cutaneous leishmaniasis. *Lancet Infect Dis* 7:581–596
- Salah AB, Kamarianakis Y, Chlif S, Alaya NB, Prastacos P (2007) Zoonotic cutaneous leishmaniasis in central Tunisia: spatio-temporal dynamics. *Int J Epidemiol* 36:991–1000
- Salehi-Moghadam A, Barati M, Mpoghadam AD, Khoshdel AR, Shokouh SH, Totonchian M et al (2015) Temporal changes and mapping Leishmaniasis in military units of IRI Army. *Hormozgan Med J* 18:91–98
- Sedaghat M, Salahi MA (2010) Mapping the distribution of the important rodents reservoir in Iran. *Ann Mil Health Sci Res* 8:210–223
- Sharifi I, Nakhaei N, Aflatoonian MR, Hakimi Parizi M, Fekri AR, Safizadeh H, Shirzadi MR, Gooya MM, Khamesipour A, Nadim A (2011) Cutaneous leishmaniasis in Bam: a comparative evaluation of pre- and post- earthquake years (1999–2008). *Iran J Public Health* 40:49–56
- Shirzadi MR (2012) Guideline for Cutaneous Leishmaniasis Care in Iran. The Office of the Zoonotic Diseases, Center for Disease Control, Ministry of Health and Medical Education, Tehran [In Persian]
- Shirzadi MR, Esfahani SB, Mohebbali M, Yaghoobi-Ershadi MR, Gharachorlo F, Razavi MR et al (2015) Epidemiological status of leishmaniasis in the Islamic Republic of Iran. *East Mediterr Health J* 21:736–742
- Sudhakar S, Srinivas T, Palit A, Kar SK, Battacharya SK (2006) Mapping of risk prone areas of kala-azar (Visceral leishmaniasis) in parts of Bihar state, India: an RS and GIS approach. *J Vector Borne Dis* 43:115–122
- Talari SA, Talaei R, Shajari G, Vakili Z, Taghaviardakani A (2006) Childhood cutaneous leishmaniasis: report of 117 cases from Iran. *The Korean J Parasitol* 44:355–360
- Weina PJ, Neafie RC, Wortmann G, Polhemus M, Aronson NE, Strausbaugh LJ (2004) Old world leishmaniasis: an emerging infection among deployed US military and civilian workers. *Clin Infect Dis* 39:1674–1680
- Yaghoobi-Ershadi M, Javadian E, Tahvildare-Bidruni G (1995) *Leishmania major* MON-26 isolated from naturally infected *Phlebotomus papatasi* (Diptera: Psychodidae) in Isfahan province, Iran. *Acta Trop* 59:279–282