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The relation between climatic factors and malaria incidence in Kerman, South East of Iran

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ABSTRACT

Background and objectives: Malaria is among the most important parasitic diseases, and is one of the endemic diseases in Iran. This disease is often known as a disease related to climate changes. Due to the health and economic burden of malaria and the location of Kerman province in an area with high incidence of malaria, the present study aimed to evaluate the effects of climatic factors on the incidence of this disease.

Material and methods: Data on the incidence of malaria in Kerman province was inquired from Kerman and Jiroft Medical Universities and climatic variables were inquired from the meteorological organization of Kerman. The data was analyzed monthly from 2000 to 2012. Variations in incidence of malaria with climatic factors were assessed with negative binomial regression model in STATA11software. In order to determine the delayed effects of meteorological variables on malaria incidence, cross-correlation analysis was done with Minitab16.

Results: The most effective meteorological factor on the incidence of malaria was temperature. As the mean, maximum, and minimum of monthly temperature increased, the incidence rate raised significantly. The multivariate negative binomial regression model indicates that a 1 °C increase in maximum temperature in a given month was related to a 15% and 19% increase on malaria incidence on the same and subsequent month, respectively (p-value = 0.001). Humidity and Rainfall were not significant in the adjusted model.

Conclusion: Temperature is among the effective climatic parameters on the incidence of malaria which should be considered in planning for control and prevention of the disease.
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1. Introduction

Malaria as a parasitic disease is still a health problem in some countries, particularly in developing ones (Azizi et al., 2011; Mohammadi et al., 2011). The disease is caused by a protozoan of plasmodium type and includes four species of *Plasmodium malariae*, *Plasmodium vivax*, *Plasmodium ovale* and *Plasmodium falciparum* that is transmitted by infected female Anopheles

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mosquitoes (Azizi et al., 2011; Mozafari et al., 2012). *P. vivax* is most common species in Iran (Soleimanifard et al., 2011; Manouchehri et al., 1992). In 2007, 93% of all malaria cases were caused by *P. vivax* (Azizi et al., 2011).

The Eastern Mediterranean Region which Iran is geographically located, includes 60%of the world's at risk population and is an important region for malaria (Mohammadi et al., 2011). According to WHO reports Iran is now in pre-elimination stage. But the south eastern provinces of Iran including Sistan and Baluchestan, Hormozgan and the tropical regions of Kerman contain 95% of all of the nation's malaria cases, and are still an endemic area for malaria (Mohammadi et al., 2011; Edrissian, 2006; WHO, n.d.). The tropical weather, long transmission season, instability of ecologic conditions and environmental changes are the causes that led to malaria still remaining as a health problem in these provinces (Azizi et al., 2011).

Malaria is mainly known as a sensitive disease to climatic changes (Kim et al., 2012). The plasmodium and their transmitters (anopheles mosquitoes) are influenced by environmental factors such as temperature, humidity and rainfall. Temperature influences the life cycle of the parasite and mosquito. Rainfall provides a place for mosquito fertilization and breeding. Humidity and temperature together can influence malaria incidence (Kim et al., 2012; Craig et al., 2004). Most acute cases of malaria occur in the hot seasons. In Iran disease transmission is inconsistent and most infections occur in summer (Azizi et al., 2011).

Studies have shown that temperature has increased and precipitation has decreased in Kerman city from 1997 to 2000 (Bakhtiari, 2003). Other researchers have predicted that the average temperature in all months of the year and precipitation during the warm months in Kerman province in the 30 year periods of 2011–2040, 2041–2070 and 2071–2100; will increase in comparison to 1971–2000 (Hesami Kermani, 2007). These changes may be able to provide a better breeding situation for the mosquitoes in especially the south of Kerman province.

Due to the health and economic importance of malaria and its relevance to environmental changes and also the location of Kerman province in an endemic area, this study was conducted to investigate the effect of temperature, humidity and rainfall on the disease incidence in the southern cities of Kerman province in order to conduct more effective prevention and control programs.

2. Material and methods

Information about malaria cases in Kerman province were extracted from the available data from the Health Deputy of Kerman and Jiroft Universities of Medical Sciences. First the data from Kahnuj county, a city with most cases of malaria and then the data about other counties in the southern part of Kerman province in the neighborhood of Kahnooj county including Manoojan, Ghalehganj and Rudbar-e Jonubi counties since 2000 to 2012 were extracted monthly and recorded in Excel software.

Data about monthly meteorological variables including mean temperature, maximum and minimum temperature, rainfall and relative humidity were extracted from the synoptic station of Kerman Province Meteorological Organization from 2000 to 2012. Since the required meteorological data had not been recorded in Manoojan, Ghalehganj and Rudbar-e Jonubi counties, in all of the above mentioned years, the unknown measures were estimated by using GIS and the Kriging methods.

It is notable that by investigating the climate of Manojan, Qaleganj and Rudbar-e Jonubi according to the Demarton's aridity index, (a method of detecting regions climate according to rainfall and annual temperature), all of these counties were located in the arid climate zone. Demarton's aridity index is calculated by the following formula. In which P is the annual precipitation (mm) and T is the mean annual temperature (°C) (formula 1).

$$I = \frac{P}{T + 10}$$

Formula 1: Demarton formula for climatical classification (Kerman Meteorogical Organization, 2014).

Finally, the relation between malaria incidence and climatic factors (mean, maximum and minimum temperature, relative humidity and rainfall) was estimated with crude and adjusted negative binomial regression inSTATA11.

Table 1
The incidence rate of malaria per 100,000 people in the southern part of Kerman province in different counties in the mentioned time period.

Year	Kahnooj		Manoojan		Ghalehganj		Rudbar-e Jonubi		All cases	
	cases	incidence	cases	incidence	cases	incidence	cases	incidence	cases	incidence
2000	2488	1564.35	–	–	–	–	–	–	2488	1564.35
2001	993	661.68	–	–	–	–	–	–	993	661.68
2002	1048	742.74	–	–	–	–	–	–	1048	742.74
2003	410	310.31	127	200.20	–	–	–	–	537	274.59
2004	166	134.79	64	100.67	–	–	–	–	230	123.18
2005	740	648.10	89	139.70	–	–	–	–	829	620.17
2006	94	89.35	104	162.89	947	1347.24	13	14.84	1158	411.83
2007	688	678.34	48	75.02	387	541.19	11	12.09	1134	401.45
2008	65	66.57	23	35.87	170	233.75	9	9.54	267	94.09
2009	74	78.84	3	4.67	72	97.37	35	35.83	184	64.55
2010	30	33.31	3	4.66	13	17.30	3	2.97	49	17.11
2011	5	5.79	5	7.75	1	1.31	15	14.36	26	9.04
2012	3	3.64	0	0	0	0	2	1.86	5	1.73

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