

Original Article

A Comprehensive Database and Geographical Distribution Model of Vectors and Vector Borne Diseases in Ardabil Province, Borderline of Iran and Azerbaijan Republic 2001–2018

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Abstract

Background: Vector borne diseases (VBDs) are the infectious diseases reported from all parts of the world and Iran. The main vectors of VBDs belong to the phylum of arthropod and insects. The aim of this study was providing the database of important VBDs and vectors and geographical distribution model in Ardabil, northwest of Iran.

Methods: This retrospective cross-sectional study was conducted from 2001–2018. All the earlier published studies, reports and documentations related to vectors and vector-borne diseases searched systematically as well as the data of diseases was collected from the Center for Disease Control (CDC) of Ardabil University of Medical Sciences. ArcGIS 10.4.2 (<http://www.esri.com/arcgis>) were used to spatial analysis mapping, Normalized Difference Vegetation Index (NDVI) index and high/low clustering.

Results: Totally 110076 cases of VBDs reported in Ardabil Province during the past 18 years including malaria, visceral leishmaniasis (VL), cutaneous leishmaniasis (CL), Crimean Congo hemorrhagic fever (CCHF), tick-borne relapsing fever (TRF), pediculosis, scorpionism, scabies and anthrax. These diseases were transmitted in Ardabil Province by eight arthropod families, 19 genera and 70 species of arthropods. Most species belonged to Culicidae with 24 species followed by Psychodidae with 22 and Ixodidae with 16 species. The incidence rate of VBDs was 63/100000 in 2001 which decreased to 7/100000 in 2010 and then increased to 21 /100000 in 2018.

Conclusion: The distribution model of the VBDs was plotted based on the geographical and ecological of the vectors will help the authorities for decision.

Keywords: Vectors, Vector borne diseases, Geographical model, Ardabil, Iran

Introduction

Vector borne disease (VBDs) are the infectious diseases transmitted by the infected bite of the arthropods such as

mosquitoes, sand flies, ticks, fleas, bugs, lice and some species of flies (1, 2). Vector borne diseases are responsible for more

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than 17 percent of infectious diseases burden and more than 700, 000 deaths annually. More than 3.9 billion people in 128 countries are at risk of transmitting dengue fever which is estimated to be happening 96 million per year. Malaria causes more than 400,000 deaths annually worldwide, most of which are children under the age of five. Other VBDs like Chagas disease and leishmaniasis affect hundreds of millions of people around the world (3–5). According to the Iranian Ministry of Health, the malaria morbidity was decreased from 12294 cases in 2000 to 150 cases in 2015. WHO reported Iran to be located in pre-elimination phase (6–7). The incidence of Dengue fever has increased 30–fold in the last 50 years and 50–100 million Dengue happen every year in the world (8). According to the latest study, the incidence of CL in Iran has decreased from 174/100000 to 124/100000 cases while the spatial distribution of CL and VL has increased in new places(9). The important VBDs occurring in Iran include Visceral Leishmaniasis (VL), Cutaneous Leishmaniasis (CL), Crimean Congo Hemorrhagic Fever (CCHF), Tick Relapsing Fever (TRF), Malaria, Pediculosis (10–11). The most important endemic area for VL is the northwest of Iran. Recently, some VBDs such as the pediculosis epidemic were increased in Ardabil Province (12). The incidence of VL in Ardabil Province was increased from 2.9 in 2009 to 9.2 /100000 in 2015 and the new sides was increased to 2 time (13). The main vectors' ecology and biology of VBDs as well as its spatial distribution should be identified for prevention and control (14–15). The most important factors affecting the life cycle, growing, developing, reproduction and the survival of generations of arthropods and insects include environment temperature, relative humidity, rainfall, altitude, vegetation, amount of food and suitable shelters (16–17). The aim of this study was to establish a database of VBDs and their vectors, and to determine their spatial distribution model in Ardabil Province.

Materials and Methods

Study area

Ardabil Province is located in the northwest of Iran (37.45–39.42° N, 47.30–48.55° E), near the border of Azerbaijan Republic. The province has an area of 17,953 km² with 1,247,042 populations according to the last census conducted in 2015. The province consists of 10 counties, 21 districts, 26 cities, 71 rural districts and 1477 permanent villages. About 2/3 of the Ardabil Province is mountainous areas and the remaining is plains. The occupation of most people is farming and animal husbandry (Fig. 1) (18).

Data collection

Data were collected from the Center for Disease Control (CDC) of Ardabil University of Medical Sciences from 2001–2018 and classified by location, years, months and type of diseases. The vectors database was collected according to the last studies (projects and thesis) in Ardabil Province from 1950–2018. Previous studies, reports and documentations related to vectors and vectors borne diseases in Ardabil Province were searched in International databases such as Cochrane, MEDLINE/PubMed, Google Scholar, Science Direct, Scopus, Web of Science, Veterinary information network, Vet Med Resource, Zoological Records, Biological Abstracts, CAB Abstracts as well Iran's databases (for Persian articles) including Iran Medex, Scientific Information Iran Medex, Scientific Information Database (SID) and Magiran. Meteorological data were obtained from the Ardabil Meteorological Center during the study period. The data included annual precipitation, average annual temperature, altitude, and relative humidity.

Data and spatial autocorrelation analysis

ArcGIS 10.4 (<http://www.esri.com/arcgis>) was used for spatial analysis and mapping. NDVI (Normalized difference in vegetation index, and was also used to determine high risk areas of the disease

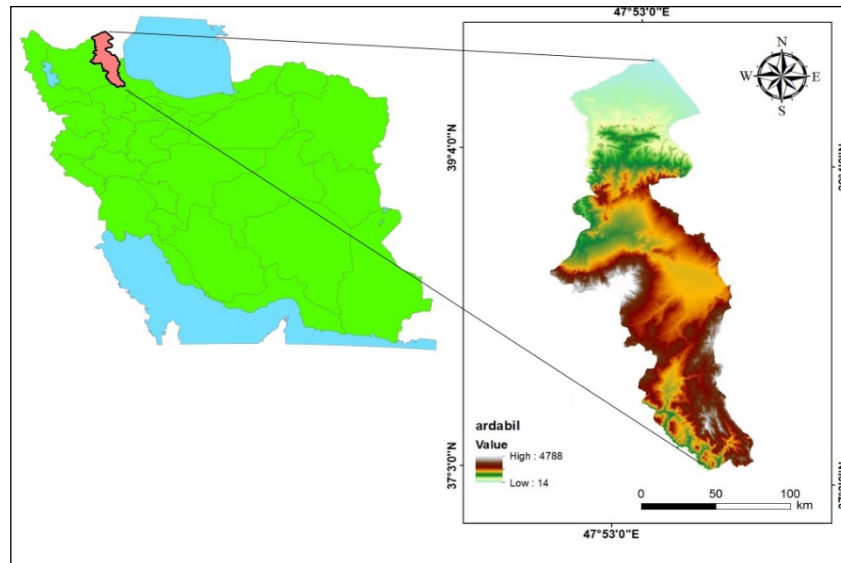


Fig. 1. The study area in North West of Iran

across the study area.

Moran's I Index and General G value were measured, and both the score and p-values ($p < 0.05$) were calculated and used to evaluate the significance of the index. Moran's I is a commonly used indicator of spatial autocorrelation. In this study, global Moran's I was used as the first measure of spatial autocorrelation.

Ethics approval and consent to participate

This study was approved by the Ethical Committee of Ardabil University of Medical Sciences, Iran (Code of ethics: IR. ARUMS. REC.1397.261).

Results

Totally 110076 cases of VBDs were reported in Ardabil Province during the past 18 years including nine different types such as malaria, VL, CL, CCHF, TRF, pediculosis, scorpionism and anthrax. The highest infectivity belongs to pediculosis (96.47%) and the lowest to CCHF (0.007%). The incidence rate of diseases excluding pediculosis was 63/100000 in 2001, which decreased to 7/100000 in 2010, and then it increased to 21/100000 in 2018. The prevalence of pediculosis was increased 110 times during 2001(16/100000) to 2018

(1768/100000). The most pediculosis cases have occurred in schools (Table 1 and Fig. 2). The results of this study showed that in the past 18 years, ABDs were transmitted by eight families, 19 genera and 70 species of arthropods in Ardabil Province. Most species belonged to Culicidae with 24, Psycodidae with 22 and Ixodidae with 16 species (Table 2).

The climate of Ardabil Province is divided into three parts in north, central and south. The northern part located in the Azerbaijan Republic borderline with low altitude, minimum precipitation, moderate NDVI, maximum annual temperature, maximum RH, in this part the most important VBD is malaria. In the central part located around Sabalan skirt with high altitude (altitude = 4,811 m), moderate precipitation, over average NDVI, moderate average temperature, low RH in the central climate, the main VBD is VL. The southern part is located in the neighborhood of Guilan Province covered mainly by forests which its climate characterized by high altitude, high precipitation, high NDVI, low annual temperature, moderate RH. The main VBD is RTF in south parts of province.

Malaria: Totally 931 cases were reported which more than 98% of them

Table 1. The species of Vector-Borne diseases vectors in Ardabil Province, northwest of Iran (2001–2018)

Class	Order	Family	Genus	Spices (adult and larva)	References				
Insecta	Diptera	Culicidae	<i>Anopheles</i>	<i>An. Maculipennis</i> , <i>An. Hyrcanus</i> , <i>An. Superpictus</i> , <i>An. Claviger</i> , <i>An. sacharovi</i> , <i>An. superpictus</i> , <i>An. pseudopictus</i>	(19, 20)				
			<i>Culex</i>	<i>Cx. hortensis</i> , <i>Cx. modestus</i> , <i>Cx. pipiens</i> , <i>Cx. theileri</i> , <i>Cx. torrentium</i> , <i>Cx.</i> <i>tritaeniorhynchus</i> , <i>Cx. perexiguus</i> , <i>Cx. mimeticus</i>					
			<i>Aedes</i>	<i>A. caspius</i> s.l., <i>A.vexans</i> , <i>A. flavescens</i>					
			<i>Culiseta</i>	<i>Cs. annulata</i> , <i>Cs. longiareolata</i> , <i>Cs. subochrea</i>					
			<i>Dahlia</i>	<i>Da. geniculatus</i>					
			<i>Coquillettidia</i>	<i>Coquillettidia richiardii</i>					
			<i>Uranotaenia</i>	<i>Uranotaenia unguiculata</i>					
			Insecta	Diptera		Psychodidae	<i>Phlebotomus</i>	<i>Ph. perfiliewi</i> , <i>Ph. papatasi</i> , <i>Ph. sergenti</i> , <i>Ph. tobbi</i> , <i>Ph. major group</i> , <i>Ph. caucasicus</i> , <i>Ph. weyoni</i> , <i>Ph. elenora</i> , <i>Ph. major</i> , <i>Ph. mongolensis</i> , <i>Ph. kandelakii</i> , <i>Ph. caucasicus group</i> , <i>Ph. andrejevi</i> , <i>Ph. halepensis</i> , <i>Ph. longiductus</i> , <i>Ph. balcanicus</i> , <i>Ph. brevis</i> , <i>Ph. chinansis group</i> , <i>Ph. simici</i> , <i>Ph. jacusieli</i>	(13, 21–25)
<i>Sergentomyia</i>	<i>Se. sintoni</i> , <i>Se. dentata</i>								
Argasidae	<i>Ornithodoros</i>	<i>Ornithodoros lahorensis</i> , <i>O. tholozani</i>							
	<i>Argas</i>	<i>Argas persicus</i> , <i>A. reflexus</i>							
	<i>Dermacentor</i>	<i>Dermacentor marginatus</i> , <i>D. niveus</i> , <i>Hy. anatolicum</i> , <i>Hy. asiaticum</i> , <i>Hy. aegyptium</i> , <i>Hy. detritum</i> , <i>Hy. Dromedarii</i> , <i>Hy. Marginatum</i> , <i>Hy. turanicum</i> , <i>Hy. schulzei</i>							
Arachnida	Ixodida	Ixodidae			<i>Hyalomma</i>		<i>Hy. anatolicum</i> , <i>Hy. asiaticum</i> , <i>Hy. aegyptium</i> , <i>Hy. detritum</i> , <i>Hy. Dromedarii</i> , <i>Hy. Marginatum</i> , <i>Hy. turanicum</i> , <i>Hy. schulzei</i>	(26–29)	
					<i>Haemaphysalis</i>		<i>H. choldokovskyi</i> , <i>H. erinacei</i> , <i>H. inermis</i> , <i>H. punctate</i> ,		
					<i>Rhipicephalus</i>		<i>R. bursa</i> , <i>R. sanguineus</i>		
					Sarcoptiformes		Sarcoptidae		
Scorpiones	Scorpionidae	<i>Scorpio</i>			<i>Scorpio maurus</i>		(30–32)		
	Buthidae	<i>Mesobuthus</i>	<i>Mesobotus eupeus</i>						
Insecta	Phthiraptera	Pediculidae	<i>Pediculus</i>	<i>Pediculus capitis</i>	(12, 33)				

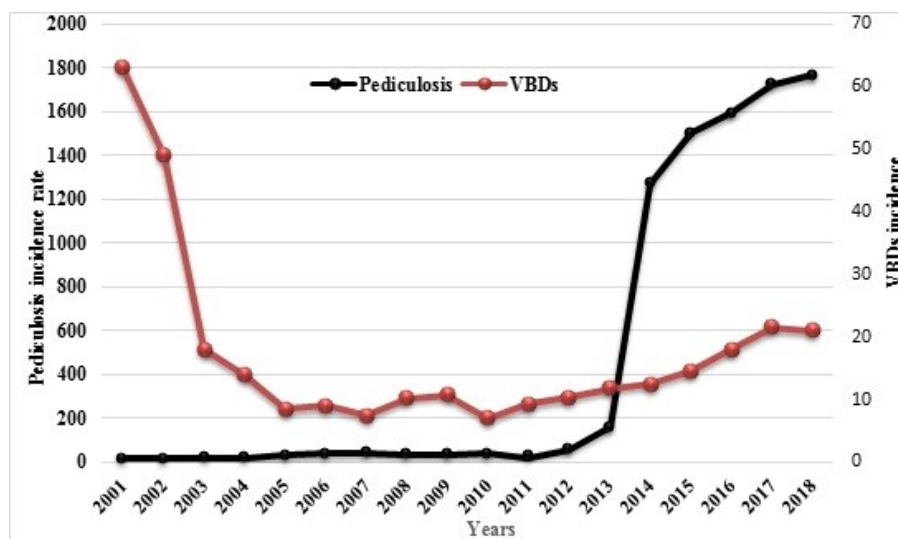


Fig. 2. The prevalence rate of Vector-Borne diseases in Ardabil Province, northwest of Iran (2001–2018)

reported in northern and 2 % in central parts of province. Since 2005, there was no report on Malaria case in this province (Figs. 3 and 7). 55 % of patients were male and 45% female from them 70% located in rural and 30 % in urban area. More than 99% of the malaria cases were proved *Plasmodium vivax* and remaining 1% was not identified. So far, four adult and six larva stage of *Anopheles* have been reported, the most abundant form in adult was *An. claviger* followed by *An. hyrcanus* and *An. superpictus*. Totally 17 species of the subfamily Culicinae were reported in Ardabil Province. Except for malaria, only

one study has been conducted on mosquito-borne diseases in Ardabil Province. The larvae of *Setaria labiatopapillosa* and *Dirofilaria immitis* were found in *An. maculipennis* and *Cx. theileri*, respectively. Eight species of *Culex*, three species of *Culiseta*, three species of *Aedes*, *Dahlia geniculatus*, *Coquillettidia richiardii* and *Uranotaenia unguiculata* (Table 2). The results of malaria spatial autocorrelation showed that the general G Index 0.023755 value, z-score of 2.47999448315, there is a less than 5% likelihood that this high-clustered pattern could be the result of random chance (P = 0.0131) (Fig. 7A).

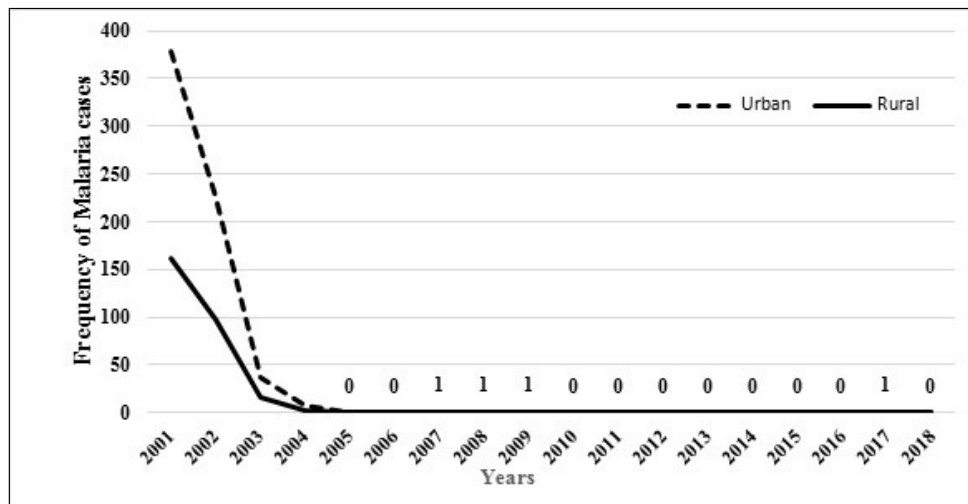


Fig. 3. The frequency of malaria cases in Ardabil Province, northwest of Iran (2001–2018)

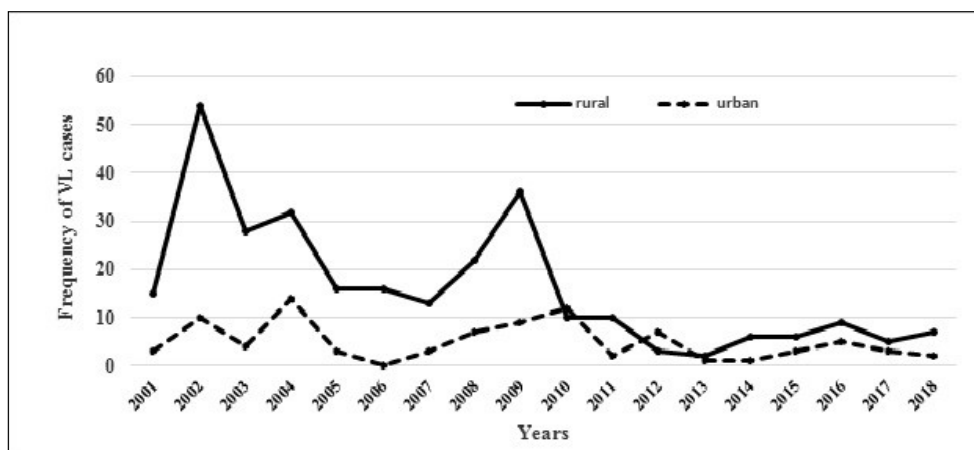


Fig. 4. The frequency of Visceral Leishmaniasis cases in Ardabil Province, northwest of Iran (2001–2018)

Visceral leishmaniasis (VL): VL is a zoonotic disease and one of the important endemic diseases in Ardabil. During the study, 379 cases of the disease were reported. VL is reported mostly in central and northern part while in the southern part are sporadic (Figs. 4, 7). The highest prevalence of VL were reported in Meshgin shahr (50%) and Germe (20%). 64% of the disease occurs in rural areas and 36% in urban with male to female ratio of 2/1. More than 85% of reported cases were children under 10 years. *L. infantum* is the causative agent of VL in these areas. The most important reservoirs of this disease are canids which its infection rate increased from 5% in 2000 to 38% in 2018. VL Parasites have been isolated and reported from human, dogs, wolves, fox and jackal in the Ardabil Province. 22 species of sand flies were identified and reported in this area from them three species (*Ph. kandelakii*, *Ph. perfilewi* and *Ph. tobbi*) has been confirmed by parasitological and molecular methods to *L. infantum*. *P. kandelakii* distributed in central and *Ph. perfilewi* and *Ph. tobbi* in northern parts of Ardabil Province. The results of VL spatial autocorrelation showed that the general G Index 0.006569 value, z-score of 0.918861150657, the pattern does not appear to be significantly different than random (P = 0.358) (Fig. 7A).

Cutaneous leishmaniasis (CL): Totally 412 cases of CL were reported in this area which the annual incidence rate was 2–5/100000 (Figs. 5 and 6). The causative agent of CL not identified in Ardabil Province. CL were reported from seven counties (Bilehsavar, Germe, Parsabad, Ardabil, Khalkhal, Nir and Namin) of the province. 50% of cases had a history of travel to endemic areas of CL. From 22 species of sand flies, two species *Ph. papatasi* and *Ph. sergenti* had the highest frequency. *Phlebotomus papatasi* and *Ph. sergenti* were collected in all parts of province but the parasite species was not identified. The CL reservoirs of infection has been reported from the *Meriones libycus*. The results of CL spatial autocorrelation showed that the general G Index 0.000037 value, the z-score of 6.80150065796, there is a less than 1% likelihood that this high-clustered pattern could be the result of random chance (P = 0.000). (Fig.6A).

Tick-borne Relapsing Fever (TRF): TRF has been reported in the southern regions of Ardabil Province for a long time. 400 cases of this disease were reported, of which 94% were in rural and 6% urban areas. 52% were female and 48% male and 88% of cases were under the age of 20 year

Table 2. The frequency of Vector-Borne diseases in Ardabil Province, northwest of Iran (2001–2018)

year	Malaria	Visceral leishmaniasis	Cutaneous leishmaniasis	Tick relapsing fever	Lice	Anthrax	Scorpionism	scabies	CCHF	Total	Prevalence
2001	541	18	32	124	200	5	42	3	1	966	79.5
2002	323	64	23	120	187	6	55	5	0	783	64.3
2003	53	32	32	56	295	2	41	2	1	514	42
2004	10	46	21	44	289	0	48	1	0	459	37.6
2005	0	19	19	22	372	1	43	0	0	476	39
2006	0	16	30	14	481	0	48	1	1	591	48
2007	1	16	20	6	533	0	49	0	0	625	50.8
2008	1	29	27	6	420	8	55	1	0	547	44.3
2009	1	45	31	4	425	0	52	0	1	559	45
2010	0	22	17	2	494	2	37	6	0	580	46.7
2011	0	12	13	1	359	0	87	3	0	475	38
2012	0	10	18	0	715	0	101	1	0	845	67.7
2013	0	3	19	0	1981	1	125	0	0	2129	170
2014	0	7	25	0	15987	0	119	1	1	16140	1286
2015	0	9	16	0	18961	0	155	4	0	19145	1519.5
2016	0	14	21	0	20148	2	182	5	0	20372	1613
2017	1	8	25	0	21879	2	222	8	2	22147	17.47
2018	0	9	23	1	22465	0	214	10	1	22723	1789
Total	931	379	412	400	106191	29	1675	51	8	110076	–

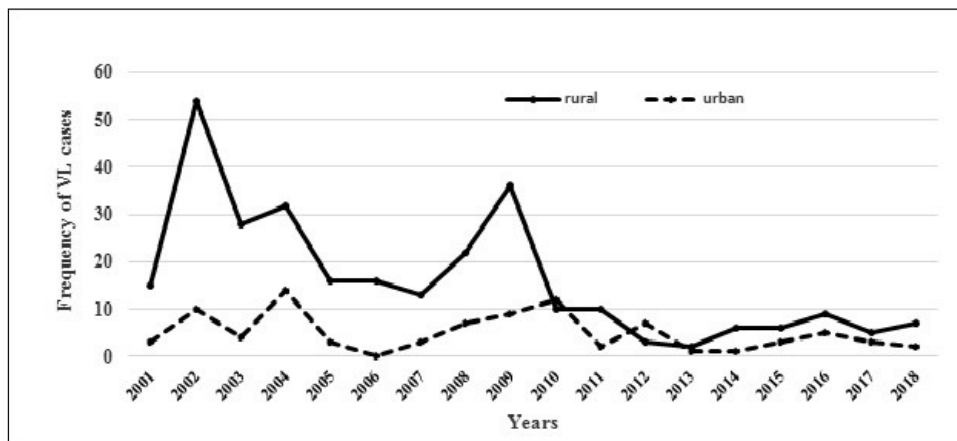


Fig. 5. The frequency of Cutaneous Leishmaniasis cases in Ardabil Province, northwest of Iran (2001–2018)

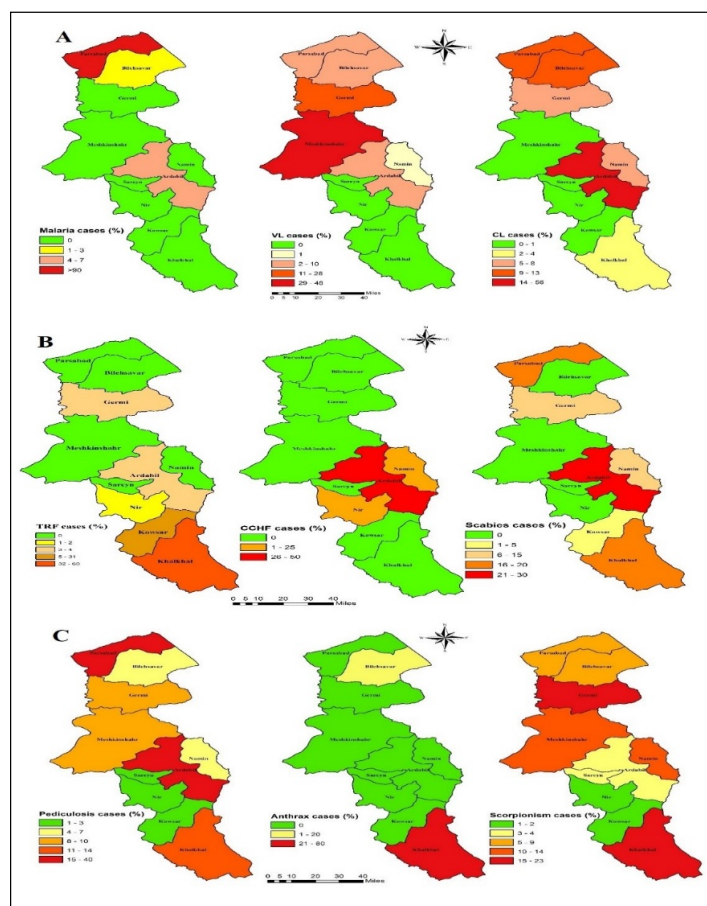


Fig. 6. Distribution of malaria, visceral leishmaniasis, cutaneous leishmaniasis (A), tick relapsing fever, CCHF, scabies (B) and pediculosis, anthrax, scorpionism (C) in Ardabil Province, northwest of Iran (2001–2018).

(Figs. 6 and 9).

More than 91% of cases have been reported from southern parts and 9% from other areas of province. Four species of soft ticks; *Ornithodoros lahorensis*, *O.*

tholozani and *Argas persicus*, *A. reflexus* have been reported that the *O. lahorensis* with 46% and the *O. tholozani* 40% had the high frequencies. The species of *Borrelia* has not been studied and identified in the

Table 3. The frequency of Vector-Borne diseases data on the most important climate factors in Ardabil Province, northwest of Iran (2001–2018)

ABDs	No.ABDs	Infected county (%) of 10	Infected village (%) of 1477	Infected city (%) of 26	Infected districts (%) of 21	Infected Rural districts (%) of 71	Topography of area	NDVI %	Average altitude (m)	Average of annually Temperature ©	Average of annually RH %	Precipitation (mm)
Malaria	931	3(30)	18	4	2	12	Plain	0.21–0.6	15–500	14–16.5	66–70	290–330
VL	379	6(60)	93	12	14	36	Mountain, Valley and hill	0.41–0.86	510–2000	10.1–14	55–65	330–400
CL	412	7(70)	35	20	19	56	Plain, hill	0.41–0.86	510–2000	10.1–14	55–65	330–400
TRF	400	2(20)	15	3	5	18	Mountain	0.6–0.86	1600–2500	8.94–12	55–60	370–430
Lice	106191	10(100)	1395	26	21	71	Mountain, Valley, hill, plain	0–0.86	15–2600	8.94–16.5	55–70	290–430
Anthrax	29	2(20)	11	2	3	4	Mountain	0.6–0.86	1600–2500	8.94–12	55–60	370–410
Scorpionism	1675	8(80)	118	21	18	48	Plain, Mountain	0–0.41	15–2600	8.94–14	55–70	330–430
Scabies	51	3(30)	4	2	3	7	Mountain	0.6–0.86	1500–2600	8.94–14	55–65	370–430
CCHF	8	3(30)	8	4	3	8	Mountain, Plain	0–0.86	15–2600	8.94–14	55–70	290–400

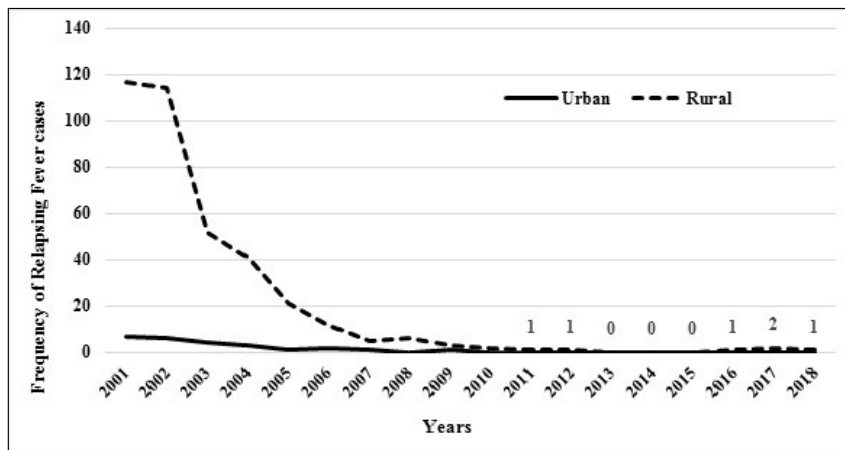


Fig. 7. The frequency of Tick-borne Relapsing Fever cases in Ardabil Province, northwest of Iran (2001–2018)

region. However, in a study conducted in 2004, the infection rate of *Borrelia Sp* in the three-tick species as; *O. lahorensis*, *O. tholozani* and *A. persicus* was 14.33% in 2004. The infectious of *O. tholozani* was estimated to be 17.5% in 2005. The results of TRF spatial autocorrelation showed that the general G Index 0.000108 value, the z–

score of –0.416500980084, the pattern does not appear to be significantly different than random (P = 0.677). (Fig. 6B).

Crimean–Congo Hemorrhagic Fever (CCHF): In the province of Ardabil, CCHF is sporadic as 8 cases have been reported over the past 18 years (Figs. 7, 6B). All cases were

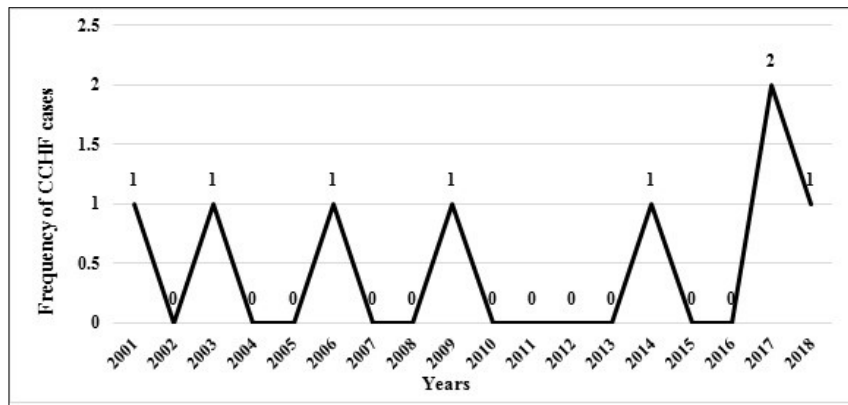


Fig. 8. The frequency of Crimean–Congo Hemorrhagic Fever cases in Ardabil Province, northwest of Iran (2001–2018)

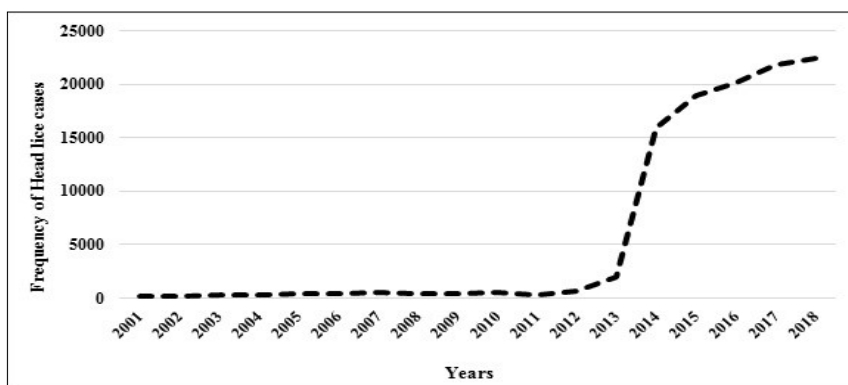


Fig. 9. The frequency of pediculosis in Ardabil Province, northwest of Iran (2001–2018)

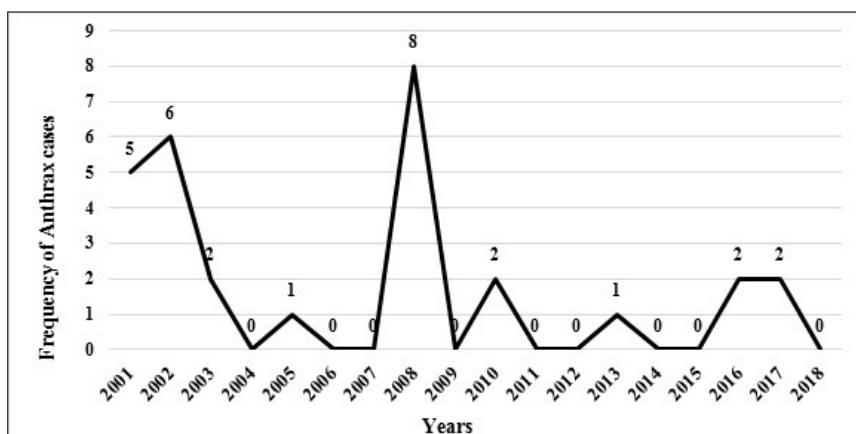


Fig. 10. The frequency of anthrax in Ardabil Province, northwest of Iran (2001–2018)

from rural areas in rancher or farmer. Patients had a history of contact with animals, tick bites and no death has been reported. Totally 20 species of soft and hard ticks were reported

in Ardabil Province (Table 2). CCHF virus infection has been reported from five species by RT–PCR methods. The infection rate were in *H. marginatum*, *H. dromedarii* and

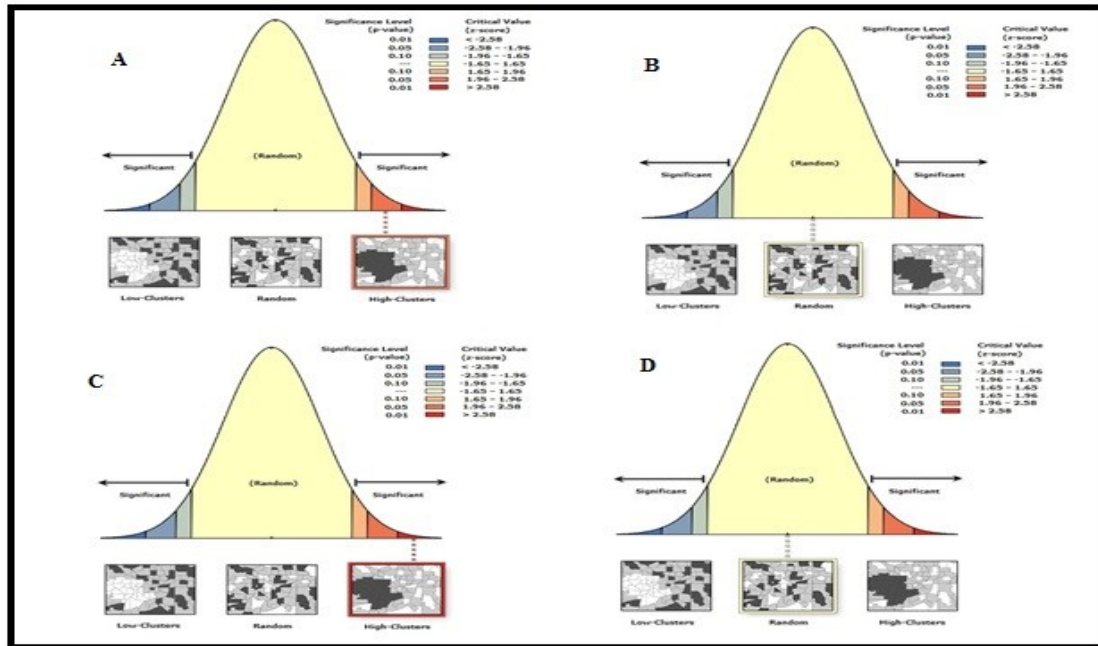


Fig. 11. General G index for high/low clustering of malaria (A), Visceral leishmaniasis (B), Cutaneous Leishmaniasis (C) and Tick-Borne Relapsing Fever (D) in Ardabil Province, northwest of Iran (2001–2018)

H. schulzei (0.8%), *R. bursa* (13.84 %) and *O. lahorensis* (6.92 %).

Scabies: 51 cases of scabies were reported in this area. The disease has been integrated into the health care system of the Iranian Ministry of Health since 2016. 65% of the disease was reported in male and 35 % in female. More than 60% of cases were in rural areas and 40% urban (Fig. 6B).

Scorpionism: A total of 1675 cases of scorpion bites occurred in the province during 2001–2018. The incidence of the scorpionism is between 12–20% per 100,000 people. The highest cases (25%) were reported from Khalkhal in south part and the lowest from Nir county in central part (1.5%). 57% were male and 43% female, and most cases (43%) were in the 10–20 years old and the lowest (18%) over the age of 70 years. 58% scorpion bites were occurred in homes and 42% outside homes. Scorpionisms have been increased more than two times since 2015. Most scorpion’s bites occurred in October (73%) and November (72.5%) (Figs. 1, 6C).

Pediculosis: During the study, 106191 cases of head lice infestation were reported in Ardebil Province. Since 2013, pediculosis has doubled and then is increasing exponentially. 40% of cases have been reported from the central and 28.5% in the northern parts of the province. More than 80% of the cases have been reported in school students. Until 2014, most cases were reported from rural areas, but after which 65% of the cases were reported from urban and peri-urban areas. The prevalence of pediculosis was increased from 44/100,000 in 2001 to 1,780/100,000 in 2018 year (Figs. 9, 6C).

Anthrax: The disease was mostly observed in the southern and northern regions. 29 cases were reported from which 90% were in southern parts and 10% of northern parts (Figs. 10–7C).

Discussion

According to the WHO reports, annually more than one billion people are affected by VBDs leading to one million deaths. The important distributed VBDs in world include

malaria, Dengue fever, schistosomiasis, leishmaniasis, Chagas disease, yellow fever, lymphatic filariasis and onchocerciasis (4). Malaria was also seemed in the northern parts of Ardebil which is one of the oldest endemic areas in borderline of Azerbaijan Republic. The cases of malaria have been zero since 2004 in Ardabil Province maybe due to plan to eradication of malaria in Iran (19). Similar to the pattern of global dispersion of *P. vivax*, the main cause of malaria in northwestern Iran is also *P. vivax* (20).

Ardabil Province is one of the most important endemic foci of visceral leishmaniasis in Iran. In recent years, cases of VL have been reduced, but geographical dispersion has increased and new sides were reported. This pattern is also observed in India (21), Brazil (22) and previous report from Ardabil (13). Most of the cases of VL were recorded in the Meshgin shahr and Germe counties with significant differences from other areas ($P > 0.05$). In these areas, most of the residents are farming and animal husbandry who keep dogs. The main reservoirs of VL are dogs and canids (23). Large numbers of reservoirs may be one of the reasons to high prevalence of the disease in these areas. Increasing the prevalence of canine visceral leishmaniasis (11) and distribution of infected dogs in different parts of the region is one of the most important causes of the distribution of VL in new sides in the areas. The high diversity of sand fly species, high infection of reservoirs and high numbers of livestock has led to a high prevalence of VL in the northwest of Iran.

CL is a non-endemic disease in north-west of Iran. The incidence rate of CL is a 2–5/100,000. The highest reported incidence was 27.5/100,000 in Iran (24). Therefore, the Ardebil Province is among the regions with a low incidence. The main challenge is that, 47% of cases are children with no history of travel to endemic areas. So far, the causative agent of CL has not been detected in this area. There is a need for further study in this area, because according to the findings of this study, the province of Ardebil is likely to be an endemic area with

a moderate prevalence. The most important Tick-Borne Diseases (TBD) reported in the Ardabil Province is CCHF. According to the results of this study, TBD are increasing in some parts of Iran as the latest reported in the International Conference of CCHF, the increasing and spread of the disease in the Eastern Mediterranean have been confirmed (25–26). The most important factors that may effect on TBD prevalence in northwest of Iran includes high population density, high livestock rates, mountainous region and high rainfall that causes animal husbandry and number of livestock have increasing. As livestock increases the number of ticks increases and which lead to high incidence of TBD. One of the other causes could be the increase in smuggling of infected animals across the borders of Iran.

Since 2013, the incidence of head lice infestations has increased exponentially in all parts of Iran and Ardabil Province. These epidemics are more common among primary school students. In this area, the prevalence of head lice is between 5–28 /100,000. The reported prevalence was 3–28 in Iran and 5–40/100,000 in the world (12, 27–28). According to previous studies in Ardabil Province, pediculosis cases on the outskirts of city was more than villages. It seems family size, students and their parents' history of infestation, type of bathrooms, and history of use shared hygiene items were probably risk factors associated with head lice infestation among students of primary schools in Ardabil Province (12, 29).

The results of this study showed that Malaria is reported only in the north of the province, with a lower elevation and along the Aras river bank. The diversity and abundance of Anopheles species also have been reported in this region in consistent with previous studies ($P < 0.05$) (30–32). VL and CL were reported in central part of the province and three of the most important main vectors of VL are reported. The most infection reservoirs of the VL are reported from the central part of the province (11). The matching of three factors proven vectors, main reservoirs and fauna of leishmania

parasite in this area resulted the Ardabil Province to be the most important endemic foci of VL in the northwest of Iran. Tick- and tick-borne diseases most were reported in south and central parts of Ardabil. These areas have moderate to high rainfall with denser vegetation and livestock keeping. According to the prevalence and species diversity of ticks in this area, the incidence of tick-borne diseases could be increased (33–36).

Conclusions

Suitable climate, sufficient food, appropriate habitats, high abundance of arthropod and reservoirs of ABDs are the most important factors affecting the prevalence of ABDs in Ardabil Province. The climate change and ecological environments have a direct impact on the frequency of arthropods in Ardebil Province. The fauna, the frequency of the vectors, and main reservoirs should be identified to prevent ABDs. The best method to control and prevention of ABD disease should be selected based on the geographical conditions.

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References

- Jean-Claude Dujardin , Lenea Campino, Carmen Cañavate, Jean-Pierre Dedet, Luigi Gradoni, Ketty Soteriadou, Apostolos Mazeris, Yusuf Ozbek, Marleen Boelaert (2008) Spread of vector-borne diseases and neglect of leishmaniasis, Europe. *Emerg Infect Dis.* 14(7):1013-8.
- Robert W Sutherst (2004) Global change and human vulnerability to vector-borne diseases. *Clin Microbiol Rev.* 17(1):136-73.
- Diarmid Campbell-Lendrum , Lucien Man- ga , Magaran Bagayoko , Johannes Sommerfeld (2015) Climate change and vector-borne diseases: what are the implications for public health research and policy? *Philos Trans R Soc Lond B Biol Sci.* 370(1665):20130552.
- World Health Organization (WHO) (2014) A global brief on vector-borne diseases. Available at: https://apps.who.int/iris/bitstream/handle/10665/111008/WHO_DCO?sequence=1.
- World Health Organization (WHO) (2015) Investing to overcome the global impact of neglected tropical diseases: third WHO report on neglected tropical diseases. Available at: <https://apps.who.int/iris/handle/10665/152781>.
- World Health Organization (WHO) (2014) Virginia Health Department. Vector-borne Disease control. Available at: <http://www.vdh.stat-.va.us/epidemiology/dee/vectorborne>.
- Kafil HF (2017) Malaria in Iran: Is the elimination phase? *Ann Trop Med Public Health.* 10 (4). <https://www.atmph.org/text.asp?2017/10/4/1062>.
- World Health Organization (WHO) (2012). Vector Borne Diseases–Dengue. Available at: <http://www.who.int/mediacentre/factsheets/fs387/en/index2.html/>.
- Piroozi B, Moradi G, Alinia C, Mohamadi P, Gouya MM, Nabavi M (2019) Incidence, burden, and trend of cutaneous leishmaniasis over four decades in Iran. *Iran J Public Health.* 48(Supple 1): 28–35.
- Service M (2014) *Medical Entomology for Students.* Vol.1.Cambridge University Press,London. <https://doi.org/10.1017/CBO9780511811012>.
- M Mohebbali , E Moradi-Asl , Y Rassi (2018) Geographic distribution and spatial analysis of *Leishmania infantum* infection in domestic and wild animal reservoir hosts of zoonotic visceral leishmaniasis in Iran: A systematic review. *J Vector Borne Dis.* 55(3):173-183.
- Moradiasl E, Habibzadeh S, Rafinejad J, Abazari M, Ahari SS, Saghafipour A (2018) Risk factors associated with head lice (pediculosis) infestation among elementary school students in Meshkin-shahr county, North West of Iran. *Inter J Pediat.* 6(3): 7383–7392.
- Eslam Moradi-Asl , Ahmad Ali Hanafi-Bojd , Yavar Rassi , Hassan Vatandoost , Mehdi Mohebbali , Mohammad Reza Yaghoobi-Ershadi , Shahraram Habibzadeh , Sadegh Hazrati , Sayena Rafizadeh (2017) Situational analysis of visceral leishmaniasis in the most important endemic area of the disease in Iran. *J Arthropod Borne Dis.* 11(4):482-496.
- Ana Rivero , Julien Vézilier, Mylène Weill, Andrew F Read, Sylvain Gandon (2010) Insecticide control of vector-borne diseases: when is insecticide resistance a problem?. *PLoS Pathog.* 6(8):e1001000.
- Blayneh K, Cao Y, Kwon HD (2009) Optimal

- control of vector-borne diseases: treatment and prevention. *Discrete Contin Dyn Syst.* 11(3): 587–611.
16. Tol RS, Dowlatabadi H (2001) Vector-borne diseases, development and climate change. *Integr Assess.* 2(4): 173–181.
 17. P Reiter (2001) Climate change and mosquito-borne disease. *Environ Health Perspect.* 109 Suppl 1(Suppl 1):141-61.
 18. Minahan JB (2016) *Encyclopedia of the Stateless Nations: Ethnic and National Groups Around the World.* 4: 225–229.
 19. S Azari-Hamidian , M R Yaghoobi-Ershadi, E Javadian, M R Abai, I Mobedi, Y-M Linton, R E Harbach (2009) Distribution and ecology of mosquitoes in a focus of dirofilariasis in northwestern Iran, with the first finding of filarial larvae in naturally infected local mosquitoes. *Med Vet Entomol.* 23(2):111-21.
 20. M R Yaghoobi-Ershadi , J Namazi, N Piazak (2001) Bionomics of *Anopheles sacharovi* in Ardebil Province, northwestern Iran during a larval control program. *Acta Trop.* 78(3):207-15.
 21. Palaniyandi M, Anand P, Maniyosai R (2014) Climate, landscape and the environments of visceral leishmaniasis transmission in India, using remote sensing and GIS. *J Geophys Remote Sens.* 3(3):1–6.
 22. Lara Saraiva , Camila Gonçalves Leite, Luiz Otávio Alves de Carvalho, José Dilermando Andrade Filho, Fernanda Carvalho de Menezes, Vanessa de Oliveira Pires Fiúza (2012) Information system and geographic information system tools in the data analyses of the control program for visceral leishmaniasis from 2006 to 2010 in the Sanitary District of Venda Nova, Belo Horizonte, Minas Gerais, Brazil. *J Trop Med.* 2012:254361.
 23. Mehdi Mohebbali , Homa Hajjaran, Yazdan Hamzavi, Iraj Mobedi, Shahnam Arshi, Zabih Zarei, Behnaz Akhoundi, Koroush Manouchehri Naeini, Reza Avizeh, Mehdi Fakhar (2005) Epidemiological aspects of canine visceral leishmaniasis in the Islamic Republic of Iran. *Vet Parasitol.* 129(3-4):243-51.
 24. Norouzinezhad F, Ghaffari F, Norouzinejad A, Kaveh F, Gouya MM (2016) Cutaneous leishmaniasis in Iran: results from an epidemiological study in urban and rural provinces. *Asia Paci J trop biomed.* 6(7):614–9.
 25. Anna Papa , Friedemann Weber , Roger Hewson , Manfred Weidmann , Ifthihar Koksai , Gulay Korukluoglu , Ali Mirazimi (2015) Meeting report: first international conference on Crimean-Congo hemorrhagic fever. *Antiviral Res.* 120:57–65.
 26. Shemsedin Dreshaj , Sali Ahmeti , Naser Ramadanani 3, Gresa Dreshaj , Isme Humolli , Isuf Dedushaj (2016) Current situation of Crimean-Congo hemorrhagic fever in Southeastern Europe and neighboring countries: a public health risk for the European Union?. *Travel Med Infect Dis.* 14(2):81-91.
 27. Kasiri H (2009) Epidemiology of *pediculus humanus capitis* infestation and effective factors in elementary schools of girls Ahvaz city, 2005. *Iran J Infect Dis Trop Med.* 14(2):41–5.
 28. T Koch , M Brown, P Selim, C Isam (2001) Towards the eradication of head lice: literature review and research agenda. *J Clin Nurs.* 10(3):364–71.
 29. Abbasgholizadeh N Moradi-Asl E, Adham D, Soudi R, Ganji A, Brige H (2018) Prevalence of Head Lice Infestation (*Pediculosis Capitis*) Among Primary School Students in the Meshkin Shahr of Ardabil Province. *Amrican J Ped.* 4(4):94–9.
 30. Moradi-Asl E, Hazrati S, Vatandoost H, Emdadi D, Ghorbani E, Ghasemian A (2018) Fauna and Larval Habitat Characteristics of Mosquitoes (Diptera: Culicidae) in Ardabil Province, Northwestern Iran. *J Health.* 9(3):259–66.
 31. S Azari-Hamidian , M R Yaghoobi-Ershadi, E Javadian, M R Abai, I Mobedi, Y-M Linton, R E Harbach (2009) Distribution and ecology of mosquitoes in a focus of dirofilariasis in northwestern Iran, with the first finding of filarial larvae in naturally infected local mosquitoes. *Med Vet Entomol.* 23(2):111-21.
 32. M R Yaghoobi-Ershadi , J Namazi, N Piazak (2001) Bionomics of *Anopheles sacharovi* in Ardebil province, northwestern Iran during a larval control program. *Acta Trop.* 78(3):207-15.
 33. Z Telmadarraiy , Seyed Mojtaba Ghiasi, Maryam Moradi, Hasan Vatandoost, Mohammad Reza Eshraghian, Faezeh Faghihi, Zabiollah Zarei, Ali Haeri, Sadegh Chinikar (2010) A survey of Crimean-Congo haemorrhagic fever in livestock and ticks in Ardabil Province, Iran during 2004–2005. *Scand J Infect Dis.* 42(2):137-41.
 34. Mostafavi E, Bagheri Amiri F, Khakifrouz S, Esmaeili S, Kazemi-Lomedasht F (2016) Serologic Survey of Crimean-Congo Haemorrhagic Fever among Sheep in Ardabil Province, Northwest Iran. *J Med Microbio Infec Dis.* 4(1):16–9.
 35. Vatandoost H, Moradi Asl E, Telmadarreiy Z, Mohebbali M, Masoumi Asl H, Abai MR (2012) Field efficacy of flumethrin pour-on against livestock ticks in Iran. *Inter J Acarol.* 38(6):457–64.
 36. Eslam Moradi Asl , Hassan Vatandoost , Zaki Telmadarreiy , Mehdi Mohebbali , Mohammad Reza Abai (2018) Repellency effect of flumethrin pour-on formulation against vectors of Crimean-Congo haemorrhagic fever. *East Mediterr Health J.* 24(11):1082-1087.