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Original Article

Quantitative analysis of most important infectious disease trend by climate change in Iran: Spatial trend analysis using Mann-Kendal

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ABSTRACT

Background & Aim: The aim of the study was to define the epidemiological characteristics of most important infectious diseases in Iran in recent decades.
Methods & Materials: This was a situation trend analysis of infectious diseases (vector and water borne disease, and food borne diseases) in recent decades based on data availability. Three significance levels were used for Mann-Kendall test (90%, 95% and 99%).
Results: The morbidities of most studied diseases had decreased in whole of the country. Unlike other diseases, coetaneous leishmaniasis had not followed the deacreasing trend. In terms of location, Khorasan-e-Shomali was followed the increasing pattern for in four out of six disaeses [malaria, leishmaniasis (coetaneous and visceral), and typhoid].
Conclusion: In conclusion, there is a significant decreasing trend of most important infectious diseases in Iran. Nevertheless, climate change is already happening and would influence the diseases trends. Hence, developing and implementing adaptation strategies should be considered**.**

Introduction

Weather and climate change has strong direct and indirect effects on human life, from tropical to polar areas of the world (1, 2). Climate conditions affect diseases transmitted through water or related to it, including diseases transmitted by arthropods, so that the climate-sensitive diseases are among the world's deadliest diseases (3). Climate change affects the risk of disease by influencing the life cycles of vectors; it also has a significant effect on factors such as the vector's natural environment and ecology, animals that are reservoirs for the pathogen, and human behavior. The burden of vector-borne and water-borne diseases such as malaria, leishmaniasis (coetaneous and visceral), as well as the Crimean-Congo hemorrhagic fever (CCHF), are major problems of the health system in developing countries (4-6). Disease vectors (mosquitoes, sand flies, ticks, and the agents they transmit) are highly sensitive to climatic conditions, including temperature and humidity. Therefore, changes in the mean and variance of these climatic variables can alter the incidence and geographic range of many climate-sensitive infectious diseases (3, 7, 8).

Iran has experienced the climatic hazards over several decades. The most serious ones are flood, drought, flash floods, and extreme temperatures. Some of these, especially droughts and floods, have

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increased in frequency, intensity, and magnitude over the past two decades and have adversely influenced the sustainable development (9).

Despite limited published evidence, Iran is highly vulnerable to the adverse effects of the climate change. To develop adaptation or mitigation strategies, the current situation of the most important affected issues should be quantified. The aim of the current study was to define the current situation of most important infectious diseases in Iran during recent decades.

Methods

This was a situation trend analysis of infectious diseases in recent decades based on data availability. With special focus on the major climate-sensitive health issues (both mortalities and morbidities), vector-borne and water-food borne diseases were selected. All data was obtained from Iranian Ministry of Health (MOH). For all diseases, data were gathered annually. Mann-Kendal trend test was used for detecting trend of all diseases. The trends were mapped using Geographical Information Systems (GIS). Three significance levels were used for Mann-Kendall test (90%, 95% and 99%). The final selected diseases were malaria (1998-2011), coetaneous (1981-2011) and visceral (2000-2011) leishmaniasis, and Crimean-Congo haemorrhagic fever (2000-2011) as vector-borne disaeses as well as typhoid (1981-2011) and Vibrio cholera biotype eltor (eltor) (1998-2010) as water-food borne infectious disease. All data was obtained at the province level.

Results

Malaria

The distribution of Malaria decreased in the last 14 years. The provinces being at the highest risk was the Khorasan-e-Shomali (Kendll' Tau = 0.44, P = 0.069). The decreasing trends were significant in selected levels in all provinces except Qom and Bushehr. Table 1 shows the Mann-Kendall significance levels. Figure 1 shows the trend of the morbidity from malaria from 1998 to 2011.

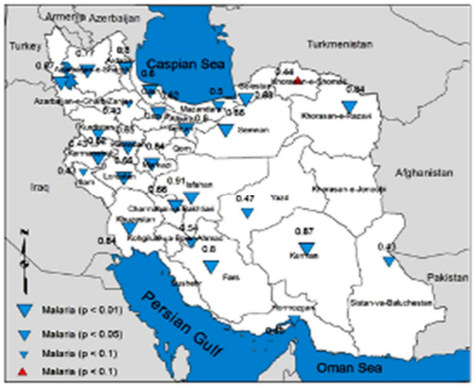

Figure 1. Trend of morbidity of malaria in Iran (1998-2011)

Cutaneous leishmaniasis

Cutaneous leishmaniasis (CL) increased in the last 30 years in all provinces except Esfahan (Kendll' Tau = -0.37, P = 0.009), Khusestan (Kendll' Tau = -0.413, P = 0.003), East Azerbaijan (Kendll' Tau = -0.355, P = 0.014), and Mazandaran (Kendll' Tau = -0.466, P = 0.001). There was a significant decrease in these provinces. Table 1 shows the Mann-Kendall significance levels. Figure 2 shows trend of morbidity of CL from 1981 to 2011.

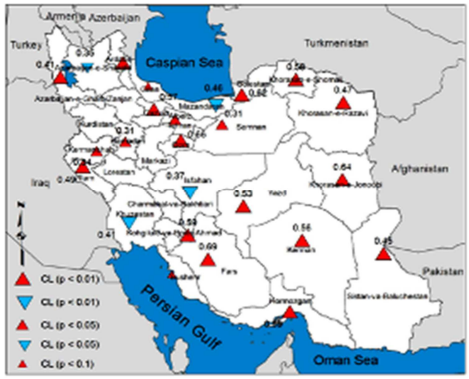

Figure 2. Trend of morbidity of cutaneous leishmaniasis in Iran (1981-2011)

Visceral leishmaniasis (VL)

During the last 12 years, an increase in VL cases occurred in three provinces including Sistan and Balochestan (Kendll' Tau = -0.532, P = 0.04), Semnan (Kendll' Tau = -0.557, P = 0.028), and North Khorasan (Kendll' Tau = -0.444, P = 0.071). Table 1 shows the Mann-Kendall significance levels. Figure 3 shows the trend of Morbidity from VL from 2000 to 2011.

Table 1. Results of Mann-Kendall trend test (0.1, 0.05 and 0.01) for vector-borne diseases

Province	P-value				Kendall's Tau			
	Malaria	CL	VL	CCHF	Malaria	CL	VL	CCHF
Alborz	-	0.021 (2)	-	-	-	0.396	-	-
Ardebil	< 0.001 (3)	< 0.001 (3)	0.001 (3)	-	-0.801	0.611	-0.739	-
Bushehr	0.101 (0)	0.093 (1)	0.002 (3)	0.777 (0)	-0.341	0.244	-0.743	-0.102
Chaharmahal	0.001 (3)	0.272 (0)	0.003 (3)	0.906 (0)	-0.656	0.161	-0.689	0.064
East Azerbaijan	< 0.001 (3)	0.014 (2)	0.002 (3)	0.724 (0)	-0.773	-0.355	-0.708	0.127
Fars	< 0.001 (3)	< 0.001 (3)	0.009 (3)	0.872 (0)	-0.802	0.693	-0.595	0.059
Golestan	0.001 (3)	< 0.001 (3)	0.237 (0)	0.126 (0)	-0.678	0.619	0.330	0.445
Guilan	0.004 (3)	0.073 (1)	0.752 (0)	0.556 (0)	-0.603	0.274	-0.099	0.191
Hamedan	0.002 (3)	0.031 (2)	0.237 (0)	0.635 (0)	-0.649	0.313	-0.330	-0.171
Hormozgan	0.026 (2)	< 0.001 (3)	1.000 (0)	0.280 (0)	-0.451	0.586	0.000	0.291
Ilam	0.062 (1)	0.001 (3)	0.452 (0)	-	-0.433	0.497	-0.220	-
Isfahan	< 0.001 (3)	< 0.001 (3)	0.618 (0)	0.472 (0)	-0.912	-0.373	0.134	0.195
Kerman	< 0.001 (3)	< 0.001 (3)	0.827 (0)	0.039 (2)	-0.868	0.560	-0.070	0.540
Kermanshah	0.003 (3)	0.018 (2)	0.434 (0)	0.131 (0)	-0.625	0.341	-0.211	0.423
Khorassan-e-Jonubi	0.860 (0)	< 0.001 (3)	0.562 (0)	0.101 (0)	0.051	0.643	0.186	0.464
Khorassan-e-Razavi	< 0.001 (3)	0.001 (3)	0.002 (3)	0.026 (2)	-0.840	0.467	-0.718	0.583
Khorassan-e-Shomali	0.069 (1)	0.000 (3)	0.071 (1)	0.429 (0)	0.440	0.576	0.444	0.256
Khusestan	< 0.001 (3)	0.003 (3)	0.045 (1)	0.375 (0)	-0.840	-0.413	-0.469	-0.239
Kohgoloieh	0.010 (2)	< 0.001 (3)	0.068 (1)	0.429 (0)	-0.536	0.570	-0.433	0.256
Kordestan	0.040 (2)	0.300 (0)	0.831 (0)	0.185 (0)	-0.435	0.156	-0.081	-0.385
Lorestan	0.002 (3)	0.297 (0)	0.626 (0)	0.542 (0)	-0.656	-0.153	-0.127	0.180
Markazi	< 0.001 (3)	0.123 (0)	0.552 (0)	0.349 (0)	-0.840	-0.224	0.174	0.278
Mazandaran	0.016 (2)	0.001 (3)	-	0.195 (0)	-0.500	-0.466	-	0.381
Gazvin	0.003 (3)	< 0.001 (3)	0.144 (0)	-	-0.619	0.568	-0.395	-
Qom	0.157 (0)	< 0.001 (3)	0.064 (1)	0.715 (0)	-0.297	0.659	-0.497	0.117
Semnan	< 0.001 (3)	0.033 (2)	0.028 (2)	0.874 (0)	-0.862	0.307	0.557	-0.085
Sistan va Balochestan	0.036 (2)	0.001 (3)	0.040 (2)	0.121 (0)	-0.429	0.453	0.532	0.382
Tehran	< 0.001 (3)	0.418 (0)	0.188 (0)	0.445 (0)	-0.802	0.120	-0.313	0.219
West Azerbaijan	0.001 (3)	0.005 (3)	0.752 (0)	0.815 (0)	-0.670	0.410	0.099	0.093
Yazd	0.019 (2)	< 0.001 (3)	0.562 (0)	0.603 (0)	-0.473	0.531	-0.186	0.155
Zanjan	0.067 (1)	0.159 (0)	0.508 (0)	-	-0.434	-0.209	-0.182	-

0: Not significant, 1: Significance < 1, 2: Significance < 0.05, 3: Significance < 0.01
CL: Coetaneous leishmaniasis, VL: Visceral leishmaniasis, CCHF: Crimean-Congo haemorrhagic fever

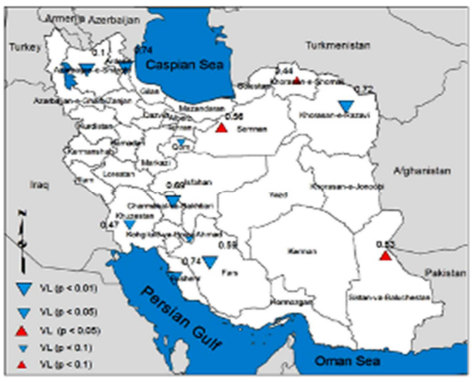

Figure 3. Trend of morbidity of visceral leishmaniasis in Iran (2000-2011)

Crimean-Congo hemorrhagic fever

Crimean-Congo hemorrhagic fever (CCHF) increased in the last 12 years in Razavi Khorasan (Kendll' Tau = -0.583, P = 0.026) and Kerman (Kendll' Tau = -0.540, P = 0.039). The increasing trend in these provinces was significant. Table 1 shows the Mann-Kendall significance levels. Figure 4 shows trend of morbidity of CCHF from 2000 to 2011.

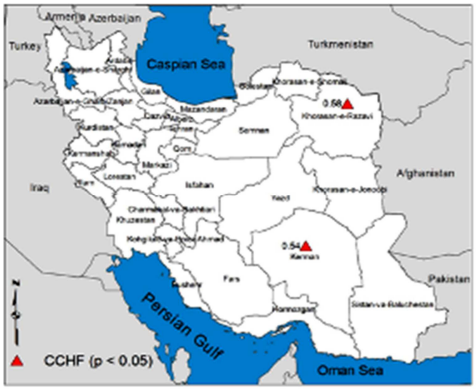

Figure 4. Trend of morbidity of Crimean-Congo haemorrhagic fever in Iran (2000-2011)

Typhoid fever

The distribution of typhoid fever decreased in the last 30 years. North Khorasan was the province with the highest risk. Decreasing pattern were significant in all provinces in selected levels but in Qom (Kendll' Tau = -0.085, P = 0.834), South Khorasan (Kendll' Tau = -1.000, P = 1.000), Ardebil (Kendll' Tau = -0.257, P = 0.149), and Golestan (Kendll' Tau = -0.286, P = 0.566). Table 2 shows the Mann-Kendall significance levels. Figure 5 shows trend of morbidity of typhoid from 1981 to 2010.

Eltor

The distribution of eltor decreased in the last 12 years. Decreasing pattern in the most provinces were significant in selected levels. Table 2 shows the Mann-Kendall significance levels. Figure 6 shows trend of morbidity of eltor from 1998 to 2010.

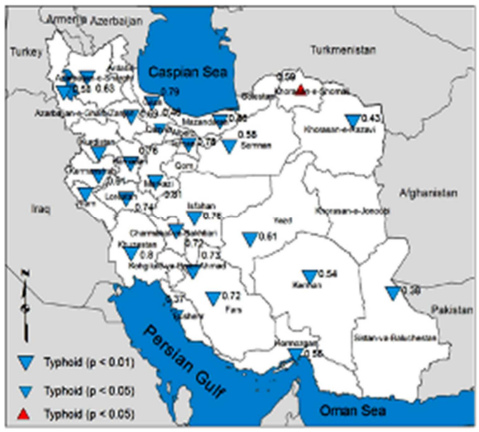

Figure 5. Trend of morbidity of typhoid fever in Iran (1981-2010)

Table 2. Results of Mann-Kendall trend test (0.1, 0.05 and 0.01) for water-food borne diseases

Province	P-value		Kendall's Tau	
	Typhoid	Eltor	Typhoid	Eltor
Alborz	-	-	-	-
Ardebil	0.149 (0)	0.164 (0)	-0.257	-0.447
Bushehr	0.012 (2)	0.922 (0)	-0.371	-0.053
Chaharmahal	< 0.0001 (3)	-	-0.720	-
East Azerbaijan	< 0.0001 (3)	0.164 (0)	-0.631	-0.447
Fars	< 0.0001 (3)	0.164 (0)	-0.718	-0.447
Golestan	0.566 (0)	0.077 (1)	-0.276	-0.484
Guilan	< 0.0001 (3)	0.019 (2)	-0.789	-0.669
Hamedan	< 0.0001 (3)	0.605 (0)	-0.759	-0.181
Hormozgan	< 0.0001 (3)	0.796 (0)	-0.563	-0.108
Ilam	< 0.0001 (3)	0.164 (0)	-0.570	-0.447
Isfahan	< 0.0001 (3)	0.047 (2)	-0.765	-0.523
Kerman	< 0.0001 (3)	0.120 (0)	-0.545	-0.470
Kermanshah	< 0.0001 (3)	0.038 (2)	-0.611	-0.615
Khorassan-e-Jonubi	1.000 (0)	1.000 (0)	-1.000	0.000
Khorassan-e-Razavi	0.001 (3)	0.019 (2)	-0.430	-0.669
Khorassan-e-Shomali	0.035 (2)	-	0.588	-
Khusestan	< 0.0001 (3)	0.113 (0)	-0.797	-0.435
Kohgoloieh	< 0.0001 (3)	0.164 (0)	-0.730	-0.447
Kordestan	< 0.0001 (3)	0.053 (1)	-0.764	-0.544
Lorestan	< 0.0001 (3)	0.164 (0)	-0.738	-0.447
Markazi	< 0.0001 (3)	0.360 (0)	-0.806	-0.272
Mazandaran	< 0.0001 (3)	0.025 (2)	-0.863	-0.653
Gazvin	0.022 (2)	0.605 (0)	-0.456	-0.181
Qom	0.834 (0)	0.039 (2)	-0.085	-0.539
Semnan	< 0.0001(3)	0.654 (0)	-0.580	-0.155
Sistan va Balochestan	0.003 (3)	0.009 (3)	-0.385	-0.674
Tehran	< 0.0001 (3)	0.077 (1)	-0.783	-0.484
West Azerbaijan	< 0.0001 (3)	0.050 (2)	-0.580	-0.588
Yazd	< 0.0001 (3)	0.049 (2)	-0.606	-0.547
Zanjan	< 0.0001 (3)	0.605 (0)	-0.687	-0.181

0: Not significant, 1: Significance < 1, 2: Significance < 0.05, 3: Significance < 0.01

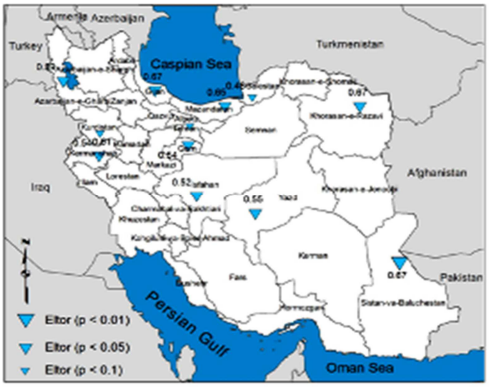

Figure 6. Trend of morbidity of eltor in Iran (1998-2010)

Discussion

This study aimed to define the current spatial situation of the most important infectious diseases in recent decades in Iran. Malaria, coetaneous and visceral leishmaniasis, CCHF as vector-borne and typhoid and eltor as water-food borne diseases were selected. They were the most important issues affected by climate change. Based on the results, the morbidities of most studied diseases were decreased almost in whole of the country. Coetaneous leishmaniasis unlike others has not followed the increasing trends. In term of the location, North Khorasan has been followed the increasing pattern for 4 out of 6 diseases (malaria, CL, VL, and typhoid). Malaria had a decreasing trend in recent decades.

A study found a downward trend the incidence trend of malaria during a 65-year period, from 1940 to 2006 (9). A 30-year study (1975-2005) assessed the climatic condition of malaria outbreak in Iran and found Climatic factors as a risk factor for increasing malaria incidence whereas the other factors were constant (10). Increasing trend of CL might be due to climate cahnge or other factors. A study evaluated the changing disease prevalence in an endemic area (11). The prevalence rate was decreased about 18 folds as compared to the previous investigation in 2005. Establishment of the CL, active case finding, and subsequent treatment seemed to be a successful model for controlling CL in the endemic countries (11). Another study was done in endemic area to compare the period prevalence in two time periods, 1990-1992 and 2010-2012, and found urban CL was extremely reflective of the environmental changes (12). The improvement of hygiene, public perception, primary health care and some other factors has changed the pattern of disease but climate change phenomena in recent years may have influenced the incidence of disease (11). Special consideration might be necessary to prevent the increasing of disease incidence in the future. About the VL, trend significantly decreased in most provinces, but it was in contrast with the epidemiological feature of the disease in south of Iran (13).

CCHF was an endemic disease in southern areas of country. The first increasing incidence has been reported since 2000. The trend analysis showed the increasing trend in Razavi Khorasan and Kerman provinces. Assessment of disease mortality rate in recent years showed the decreasing trend from 20% (2000) dropped to 6% (2007) in the country (14). Despite the decreasing trend of disease in vulnerable and endemic area, it is still needed to be considered as an important one due to high risk fatality rate in climate change context. Water-food borne disease also was studied for trend pattern and there were decreasing patterns in recent decades. It might be related to the health facilities and urbanization. Climate change may have influenced the pattern of water-food borne disease and might have caused some small epidemics of diseases.

A study found that the climate change and aging may have impact on burden of typhoid fever in the future and recommended the adaptive strategies should be considered to prevent it and reduce the health burden of climate change (15). Eltor also had significant decreasing trend in the country. The incidence of cholera was found to be significantly related to higher temperature and humidity, lower precipitation, shorter distance to the eastern border of Iran and local health centers, and longer distance to the district health centers (7). Appropriate health care and facilities in recent decades caused a significant decrease in the prevalence of disease. Climate change, may be dramatically affect the achievements.

In conclusion, most of the important infectious diseases had significant decreasing trend. Nevertheless, climate change has already happened and would influence the diseases

trends. It is important to consider the adaptation program to develop and implement the appropriate researches and programs to inform the public and policy-makers. A disease projection study under different climatic scenarios is the exclusive recommendation that no study has been published in this field so far.

The current time frame of study was per year but the results could be more reliable if the monthly or even daily occurrences of diseases apply. In addition, we did not distinguish between mortality and morbidity and all cases studied as morbidity cases that may have influenced the results.

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