AMBIENT APPRAISAL

Geographical Distribution Map of Zoonotic Diseases in Mazandaran Province of Iran Over a 10-year Period

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Study Area: Sari, Iran

Coordinates: 36°33'48"N; 53°03'36"E

Introduction:

Zoonosis types of diseases or infections are naturally transmitted between humans and vertebrate animals (Al-Tayib, 2019). These diseases are crucial for public health and economic impacts, and about 60% of the total pathogens are common between humans and animals (Klous *et al.*, 2016). Zoonotic diseases cause economic losses due to reduced production of livestock products and animal mortality (Kabir *et al.*, 2019). The risk of zoonotic diseases in Iran is also high (Djalalinia *et al.*, 2019). Humans suffer from zoonotic diseases due to their close association with the animal. The most important zoonotic diseases include brucellosis, leptospirosis, hydatid cysts, and anthrax.

Brucellosis is an acute or chronic infectious disease transmits between humans and a number of animals (eg. cattle, sheep, goats, pigs, and camels) through contact with livestock or animal products (Pourakbari *et al.*, 2019). Brucellosis is mostly a work-related disease and is one of the zoonotic diseases that are acute, subacute or chronic (Lytras *et al.*, 2016). In animals, the disease mostly affects the genitourinary tract, and in humans usually causes fever, sweating, weakness, and weight loss (Addis, 2015). It causes many economic losses. Infected livestock will lose weight and milk and thus will affect the economy of the community. The higher the prevalence of the disease

Abstract

The geographical distribution of Zoonotic diseases is a spatial and temporal process which an effective step can be taken by understanding the factors affecting it. This descriptive-analytical study was carried out based on the data of patients with brucellosis, leptospirosis, hydatid cyst and anthrax who referred to health centers and hospitals of Mazandaran province during 2007-2016. After necessary tests and confirmation of the disease, their information was recorded in patient-specific forms and they were treated. The results showed a significant relationship between the prevalence of brucellosis, leptospirosis, hydatid cyst, and anthrax according to the prevalence year and the studied cities. It can be concluded that northern Iran is at risk of zoonotic diseases. This information can be used by public health managers and decision-makers for control strategies and preventive measures.

Key words: Brucellosis, Leptospirosis, Hydatid Cyst, Anthrax

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among livestock, the more people would be infected, which results in enormous damages by imposing treatment costs, and disrupting farmers and ranchmen's power (Angara *et al.*, 2016; Pal *et al.*, 2017). *Brucella* is a gram-negative, small, aerobic, and non-motile bacilli which lack capsules and spores (Alizadeh *et al.*, 2018). *Brucella* spp. grow in solid medium, usually in clear, translucent, and white to amber blue colonies. However, the growth of *Brucella canis* and *Brucella ovis*, is in the form of rough and sometimes mucoid colonies (Yagupsky, 2015). The disease is present all over the world and each species of *Brucella* spp. is more abundant in some areas of the world (Cárdenas *et al.*, 2019). Human brucellosis has been currently reported from Russia, Africa, the Middle East, India, Europe, and the US. *Melitensis* is the most common *Brucella* spp. (Pappas *et al.*, 2006).

Leptospirosis is a zoonotic disease with global spread, that transmits to humans through animals. Leptospirosis is caused by a spiral-shaped, thin, highly mobile bacterium from *Leptospira* that can infect various types of wild and domestic animals. The animals also spread the infection through their urination. Common animal sources (hosts) include rodents, cattle, and pigs. Wild and domestic animals, both are reservoirs of *Leptospira*. Hydatid cyst disease is one of the most dangerous zoonotic diseases. The disease is caused by a newborn dog's intestinal parasite that

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enters the human and animal body. Adult worms live in the intestines of dogs and infants in the human body and ruminants. The cause of the disease is the neonatal stage of *Echinococcus granulosus*. Dogs and infected animals dispose the eggs through stool in the environment. Then they enter into animals' body by forage and grazing in infected pastures and larvae is released into their body and enters the vessels through the intestinal mucosa. It begins to grow in various organs, such as liver, lungs, kidneys, brain, bones, spleen, and etc. and becomes cysts.

Anthrax is one of the infectious diseases of animals caused by Gram-positive bacilli producing spores called *Bacillus anthracis*. In humans, it is caused by exposure to infected animals, or from their products. This disease not only causes high mortality in livestock, but also increases mortality in humans. Animal anthrax in temperate regions usually occur in winter, and its origin is not the bacilli found in pastures, but those found in stored forage. However, in other areas with warm and dry weather in summer, anthrax bacilli remain in the spore state and infect pastures for several years, and in the warm season when grasses wither, spores are easily eaten with plants roots. In this season, the number of flies and other insects are also high, causing organisms to move from dead carcasses to other distant animals.

In this study, in addition to examining the trends of zoonotic diseases, their geographical distribution is also mapped. Geographic Information System (GIS) provides researchers with the reality of what is going on in the environment through statistical models and readable maps. This system is used for studying the distribution of factors influenced by environmental factors and by providing the integration of data from different sources makes it possible to extract the required information and discover the relationships between different phenomena. Today, GIS has been widely used in determining high-risk regions for disease vectors. Hazard maps are a good guide for health managers in the country. This study aimed to investigate the temporal and spatial distribution of the disease over a 10-year period from 2007 to 2016 in Mazandaran province in northern Iran.

Materials and methods:

Study area: Mazandaran province, with an area of about 24,000 square kilometers, is bounded on the north by Mazandaran Sea, on the south by the provinces of Tehran, Semnan, and Qazvin and on the east by Golestan province, and on the west by Gilan province. This area enjoys diverse climates. According to the new geographical divisions of the province, there are 22 cities named Ramsar, Tonekabon, Chalus, Noshahr, Noor, Mahmoudabad, Fereidoonkar, Amol, Babol, Babolsar, Behshahr, Jouybar, Sari, Savadkoh, North Sawadkuh, Simorgh, Abbas Abad, Ghaemesh. , Kalardasht, Galooghah, Miyan Dorood and Neka. It also has 51 towns, 44 districts, 113 rural districts, and 3697 villages.

The main occupation of inhabitants in Mazandaran province is agriculture and horticulture. Mazandaran region offers temperate Caspian, temperate mountainous, and cold mountainous climate.

Type of study, the population under study, and data collection method: this descriptive-analytical study was based on the data of patients with brucellosis, leptospirosis, hydatid cyst, and anthrax, referred to health centers and hospitals of Mazandaran province during 2007-2016. After necessary tests and confirmation of the disease, their information was recorded in patient-specific forms and treatments were started. The required data was extracted from special forms and analyzed at Mazandaran University of Medical Sciences.

Data analysis: in order to map the spatial distribution of brucellosis, leptospirosis, hydatid cyst, and anthrax, the recorded data of patients referred during the study period were used. The data of these diseases was prepared over a 10-year period based on the cities of Mazandaran province and was transmitted as a layer to ArcGIS 10.2 software to illustrate the disease process in different years. The frequency maps of the studied diseases were plotted in ArcMap environment. During the study, ethical issues, preserving the individuals' reputation and social criteria, and paying attention to values were addressed. The recorded data, after coding and extracting were transferred to SPSS software (IBM, New York, USA) and analyzed using Kruskal-Wallis nonparametric statistical test.

Results:

Overall, the number of studied zoonotic diseases (brucellosis, leptospirosis, hydatid cyst, and anthrax) during the study period was 4010 cases. Demographic data of the patients with the zoonotic diseases in Mazandaran province from 2007 to 2016 were recorded and the distribution of diseases in Mazandaran province was separately investigated. There was a significant difference between the distribution of the disease in different cities of Mazandaran province ($p < 0.05$).

Brucellosis: the spatial distribution of the disease in cities of Mazandaran province was separately plotted in the study period and is shown in the figure. No case of the disease was recorded in 2007 and 2008. There was also no case of the disease during the study period in Abbas Abad and Kalardasht cities. The frequency of patients with brucellosis in different cities of Mazandaran province during 2007-2016 is presented in Table-1.

The number of brucellosis cases during the study period was 3436 cases, the lowest number was 34 cases (0.9%) belonged to Ghaemshahr and Simorgh and the highest number of patients with the disease was reported in Sari city with 588 cases (17.1%). These differences were statistically significant ($p < 0.001$). During the 10-year study period, most cases were reported in Mazandaran province

Table-1: Determining brucellosis cases in Mazandaran province divided by city, 2007-2016, number (%)

City	Year										Total (%)
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
Amol	0	0	(.7)25	(2.5)88	(1.1)38	(1.6)57	(2.2)78	(1.1)38	(1.3)46	(.8)30	(11.6)400
Babol	(2.7)93	(1.3)47	(1.01)35	(1.07)37	(.8)29	(.9)31	(1.01)35	(.9)34	(1.6)55	(.2)7	(11.7)403
Babolsar	0	0	(.2)9	(.2)7	(.1)5	(.1)4	(.3)13	(.2)7	(.2)8	(.3)13	(1.9)66
Behshahr	0	0	(.2)7	(.5)19	(.4)14	43	(1.1)38	(.9)34	(.9)34	(.2)9	(6.3)218
Tonekabon	0	0	(1.07)37	31	25	59	45	(.5)19	23	(.2)8	(7.1)247
Jouybar	0	0	0	6	10	(.3)13	18	(.2)7	(.2)7	(.1)5	(1.9)66
Chalous	0	0	(.1)5	26	36	(1.01)35	27	(.3)11	(.2)8	(1.4)51	(5.7)199
Ramsar	0	0	27	31	31	41	(.5)20	16	(.3)11	10	(5.4)187
Sari	0	0	(1.7)59	(.9)32	(2.7)95	(3.4)120	(3)105	98	71	(.2)8	(17.1)588
Savadkooh	0	0	10	(.5)20	(.4)15	(.5)19	28	(.4)15	22	19	(4.3)148
Fereidounkenar	0	0	0	3	(.05)1	(.05)2	(.1)4	(.1)4	(.1)5	(.2)9	(.8)28
Ghaemshahr	0	0	(.2)7	(.1)5	(.1)4	(.1)5	6	2	1	(.1)4	(.9)34
Galoogah	0	0	(.5)20	(.4)15	23	(.3)11	2	1	14	(.2)9	(2.7)95
Mahmoodabad	0	0	2	(.3)12	(.1)5	(.1)5	(.3)12	3	(.3)13	23	(2.1)75
Neka	0	0	(.4)15	48	48	(.9)34	(.1)5	(.2)8	(.1)4	(.1)4	(4.8)166
Noor	0	0	29	(1.1)38	(1.01)35	58	23	(.1)4	32	(.2)9	(6.6)228
Noshahr	0	0	3	18	21	28	(1.07)37	27	30	0	(4.7)164
North. Savadkooh	0	0	0	0	0	0	26	(.3)12	10	0	(1.3)48
Simorgh	0	0	0	0	0	0	0	16	18	0	(.9)34
Miyandoroud	0	0	0	0	0	0	0	0	0	(1.2)44	(1.2)44
Total (%)	93	47	(9.02%)	(12.6%)	(12.6%)	(16.4%)	(15.1%)	(10.3%)	(11.9%)	(7.6%)	3436
			310	436	435	565	522	356	412	262	

in 2012, 565 cases (16.4%) and the lowest number was in 2016, 262 cases (7.6%). These differences were statistically significant ($p=0.001$) (Fig.-1; Table-1).

Leptospirosis: the geographical distribution maps of Leptospirosis are separately illustrated during 2007-2016. The disease trend in these maps shows that the highest temporal distribution of the disease is in Sari and the least is in Abbas Abad. The presence or absence of the disease is

Table-2: Determining leptospirosis cases in Mazandaran province divided by city, 2007-2016, number

City	Year (2007-2016)										Total
	'07	'08	'09	'10	'11	'12	'13	'14	'15	'15	
Amol	0	0	2	14	1	2	5	3	5	0	32
Babol	8	8	2	26	4	0	0	0	0	0	48
Babolsar	0	0	0	5	2	0	1	3	1	4	16
Behshahr	0	0	2	2	0	4	2	3	0	5	18
Tonekabon	0	0	0	1	4	0	0	0	0	11	16
Jouybar	0	0	0	9	0	2	4	9	7	8	39
Ramsar	0	0	0	1	1	0	0	0	0	0	2
Sari	0	0	3	18	5	6	9	1	8	9	59
Miyandoroud	0	0	0	0	0	0	0	0	0	18	18
Savadkooh	0	0	1	12	0	1	0	0	6	0	20
Abbasabad	0	0	0	0	0	0	0	0	0	1	1
Fereid'nar	0	0	0	2	1	0	0	0	0	5	8
Ghaemshahr	0	0	5	19	0	1	8	12	28	49	122
Mahm'bad	0	0	0	3	3	0	3	0	0	13	22
Noor	0	0	0	2	0	1	1	0	1	3	8
Noshahr	0	0	1	1	1	1	1	0	0	3	8
Neka	0	0	0	6	0	0	3	0	5	24	38
Chalous	0	0	0	0	3	0	4	1	0	0	8
Galoogah	0	0	0	4	0	1	1	3	0	13	22
Total (%)	8	8	16	125	25	19	42	35	61	166	505

Table-3: Determining hydatid cyst cases in Mazandaran province divided by city, 2007-2016, number

City	Year (2007-2016)										Total
	'07	'08	'09	'10	'11	'12	'13	'14	'15	'15	
Amol	0	0	0	5	2	0	3	2	0	1	13
Behshahr	0	0	0	0	0	0	3	3	0	0	6
Tonekabon	0	0	0	2	1	1	0	0	1	0	5
Jouybar	0	0	1	0	0	0	0	0	1	0	2
Ramsar	0	0	0	3	1	0	0	0	0	0	4
Sari	0	0	0	0	0	2	0	2	0	0	4
Abbasabad	0	0	0	0	0	0	0	0	1	0	1
Ghaemshahr	0	0	0	0	0	0	0	2	0	0	2
Mahm'bad	0	0	0	0	0	0	0	0	1	0	1
Noor	0	0	1	1	1	1	1	0	0	0	5
Noshahr	0	0	0	0	0	0	0	0	1	0	1
Neka	0	0	0	0	0	0	0	2	1	0	3
Chlous	0	0	0	1	0	0	1	2	0	0	4
Total (%)	0	0	2	12	5	4	8	13	6	1	51

Table-4: Determining Anthrax cases in Mazandaran province divided by city, 2007-2016, number

City	Year (2007-2016)										Total
	'07	'08	'09	'10	'11	'12	'13	'14	'15	'15	
Babolsar	0	0	0	0	0	0	0	0	0	1	1
Behshahr	0	0	0	1	0	1	0	0	0	0	2
Tonekabon	0	0	0	0	1	0	0	0	0	0	1
Sari	0	0	0	0	1	0	0	0	0	0	1
Mahmouabad	0	0	0	0	0	0	0	2	1	0	3
Noor	0	0	0	0	0	0	1	3	2	1	7
Noshar	0	0	0	0	0	0	0	0	1	0	1
Chalous	0	0	0	1	0	0	0	0	0	0	1
Galoogah	0	0	0	0	1	0	0	0	0	0	1
Total (%)	0	0	0	2	3	1	1	5	4	2	18

Figure 1- Distribution of the diseases in cities of Mazandaran province during 2007-2016

shown on the map (Fig.-1). The number and percentage of patients with hydatid cyst in Mazandaran province are presented in Table-2. During the study period, 505 cases of leptospirosis were reported in all cities of the province, the highest of which was 122 cases (24.1%) in Ghaemshahr and the least was 1 case (1%) in Abbas Abad. These differences were statistically significant ($p < 0.0001$).

Hydatid cyst: geographical distribution of hydatid cyst disease is illustrated in separate maps during 2007-2016. The disease trend in these maps shows that the highest temporal distribution of the disease is in Amol city and the lowest is in Abbas Abad, Mahmoud Abad, and Noshahr. Moreover, in 2016, the disease was observed only in Amol city. The presence or absence of the disease is shown on the map (Fig.-1). The number and percentage of hydatid cyst patients in Mazandaran province are presented in Table-3. During the studied period in all cities of the province, the number of hydatid cyst cases was 51, the highest of which was 13 cases (25.4%) in Amol and the least was 1 case (1.9%) in Abbas, Mahmoudabad, and Noshahr. These differences were statistically significant ($p < 0.0001$). During study period, most cases of hydatid cyst in Mazandaran province were reported 13 cases (25.4%) in 2014 and the least number was 1 case (1.9%) in 2016 (Fig. 1, Table 3).

Anthrax: spatial distribution of anthrax disease in Mazandaran province during the studied period is shown on maps (Fig.-1). The frequency of patients with anthrax in different cities of the province during 2010-2016 is shown in Table-4. During this period, a total of 18 cases were reported in the province, the highest of which was 7 cases (33.3%) in Noor and the least was 1 case (5.5%) was in Babolsar, Behshahr, Tonekabon, Chalus, Sari, Galoogah, and Noshahr. These differences were statistically significant ($p < 0.04$). There were 18 cases of anthrax, the most number was 5 cases in 2014 (27.7%) and the least number was in 2012 and 2013 which each had 1 case (5.5%). These differences were statistically significant ($p < 0.000$) (Fig-1, Table-4).

Discussion:

The number of brucellosis cases from 2007 to 2016 was 3436, the least of which was 34 cases (9.9%) belonged to

Ghaemshahr and Simorgh and the highest number was 588 cases reported in Sari city (17.1%). Among the studied years, the highest prevalence was in 2012. The results of the study by Seyedalizadeh *et al.* (2019) in the north of the country showed that 895 patients were reported during the study period in northern Iran where Maraveh Tappeh was the most hazardous region with 60 cases per thousand people. Pakzad *et al.* (2018) reported that the average incidence rate in Iran was 38.67. Spatial analysis of brucellosis showed that this disease had spatial nature and in terms of distribution in cities, this difference was significant. Previous research studies have also shown the clustering nature of brucellosis distribution in Iran and elsewhere in the world (Seyedalizadeh *et al.*, 2019; Pakzad *et al.*, 2018). One reason for these results is the discrepancy between urban and rural populations. The performance of health care systems in the provinces may also be another reason.

The geographical distribution of Leptospirosis revealed that during ten years in all cities of the province, there were 505 cases, the highest number of which was reported 122 cases in Qaemshahr city (24.1%) and the lowest number was 1 case (1%) in Abbasabad city. These differences were statistically significant. Alikhani *et al.* (2016) in a study of healthy people in Qaemshahr showed that 18% had the disease. The results of the study by Talei *et al.* (2005) in Lorestan also showed that 48.8% of people had Leptospirosis. Moreover, the results of the study by Honarmand *et al.* (2010) in Gili showed that 59% of the subjects had positive test results in this disease. A study by Babakhani *et al.* (2016) showed that out of 200 serum samples tested, 60 samples (30%) showed positive serum levels. Therefore, it can be concluded that rice farming is directly related to this disease; furthermore, promoting appropriate farming behavior by adopting methods that minimize contact with surface water, including the use of special foot protection and socks, can play an important role in controlling the disease.

Geographic distribution of hydatid cyst disease in Mazandaran province during ten years showed 51 cases of the disease, the highest of which was 13 cases (25.4%) in Amol city and the lowest was 1 case (1.9%) in Abbasabad, Mahmoudabad, and Noshahr cities. These differences were statistically significant. The study of Saki *et al.* (2019) also indicated that the occurrence of the disease in Khuzestan province during the mentioned period is worthy of attention and it is necessary to conduct more comprehensive and up-to-date studies. These results are also in line with the study done in Babol by Ghaffari (1999). Some factors can have an impact on this issue, including lack of hygiene, marginalization, cultural and economic poverty, high population density in cities, the greater chance of being diagnosed due to easier access to diagnostic centers, presence of stray dogs, lack of repelling and inappropriately destroying slaughter waste. It is required to

educate the public about the disease and control and cut off the parasite cycle. Stray dogs appear to play a key role in establishing the parasite cycle, and a solution must be considered to control them.

Spatial distribution of anthrax in Mazandaran province during the ten-year study period showed 18 cases of the disease, the highest of which in Mazandaran was 5 cases (27.7%) in 2014 and the least was 1 case in 2012 and 2013 (5.5%). These differences were statistically significant. The results of a study conducted by Ramezanpoor *et al.* (2018) showed 117 cases of anthrax, the highest of which was in 2014 with a rate of 1.09% per 100,000 population. The trend of the disease in this study shows that 2014 had a higher incidence than other years studied. It could be due to the low safety of livestock vaccines or low animal vaccination coverage, changes in the type of vaccine or country of origin, as well as infected animals smuggled in the country, which should be investigated during a study. By increasing vaccination coverage in different regions, the incidence of human anthrax could be reduced.

Concludingly, northern Iran is at risk of zoonotic diseases. This data can be used by public health managers and decision makers for control strategies and preventive measures. Moreover, increasing the awareness of people at risk can be an effective step in preventing zoonotic diseases. Given the importance of zoonotic diseases in ensuring the safety and health of different society segments in biological defense and bioterrorism programs and the role and impact of outsourcing cooperation in the control of these diseases, continuous, close, and up-to-date cooperation of the veterinary organization with health system can play a major role in controlling the spread and prevention of the diseases.

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