RESEARCH ARTICLE

Analysis of Relationships between Altitude and Distance from Volcano with Stomach Cancer Incidence Using a Geographic Information System

F Amani[1], S Sadeghieh Ahari[2], S Barzegari[3]*, B Hassanlouei[4], M Sadrkabir[5], Esmaeil Farzaneh[6]

Abstract

    Gastric cancer (GC) is the fifth most common cancer in the world, with a wide variation in incidence rates across different geographical areas. In Iran GC is the most common cancer in males and it is reported to be the third most prevalent after breast and colorectal in females. A geographical information system (GIS) allows investigation of the geographical distribution of diseases. The purpose of the present study was to explore the relationship between gastric cancer and effective climatic factors using GIS. The dispersion distribution and the relationship between environmental factors effective on cancer were measured using Arc GIS. Of all cases, 672 (73.8%) were in males with a sex ratio of 3 to1. The highest incidence by cities was seen in Namin with 137.5 per 100,000. The results of this study showed that the distribution of GC around the Sabalan volcanic mountain was significantly higher than other places in the same province. These results can be considered as a window to future comprehensive research on gastric cancer.

Keywords: Gastric cancer - geographical information system - incidence - environmental factors - Iran

Introduction

    According to the estimations of the International Agency for Research on Cancer (IARC) in 2012, gastric cancer is the fifth most common cancer in the world (Kavousi et al., 2014), with a wide variation in incidence rates across different geographical areas. In Iran gastric cancer is the most common cancer in male and it is reported to be the third cancer after Breast and Colorectal cancers in female (Babaei et al., 2010). According to GLOBOCAN, gastric cancer in Iran accounted for 11.4% of all cases of cancer occurrence and the second most prevalent cancer and also most deadly cancer with 15.5 percent of all mortalities caused by cancers (Ferley et al., 2012). Ardabil is still one of the areas in the world that has the highest incidence of gastric cancer (Babaei et al., 2010; Sadjadi et al., 2003). Recently, the incidence and mortality rate of gastric cancer has dramatically fallen worldwide. In line with global reduction, the incidence rate of cancer has decreased in Asia as well. However, the incidence of gastric cancer in Iran remains very high at approximately 26.1 per 100,000 (Rahman et al., 2014). In most countries there is a steady decline in the incidence and mortality from gastric cancer. However in the United States, like

Iran, gastric cancer remains on the list of cancers that have a high mortality and is the reason for 2% of all deaths from cancer (Kasper et al., 2005).

    Various risk factors for stomach cancer, such as smoking, nutrition and infection with Helicobacter pylori has been identified, but other factors such as geography and ethnicity also appears to be effective against the disease.

    Despite the decline in the incidence of gastric cancer in the world but still in a developed country such as Japan and developing country such as Iran this rate is up and in fact, this reduction cannot be seen in some geographic areas.

    On the other hand, the results of several studies have shown that the incidence of gastric cancer in volcanic regions, highland (such as Japan) is higher than other regions (Jesiis et al., 1995; Dogan et al., 2009; Javier et al., 2013; Junko et al., 2014). Ardabil and East Azerbaijan provinces have these features and the dormant volcano Mount Sabalan was located in Ardabil province and Sahand in East Azerbaijan province.

    According to higher rate of mortality and gastric cancer incidence in two provinces, it seems that some geographic factors were effective in cancer incidence. So, the aim of this study was to investigate the relationship between the

[1]Biostatistics, [2]Community Medicine, [5]Internal Medicine, [5]Department of Forensic Medicine and Toxicology, Ardabil University of Medical Sciences, Ardabil, [3]Department of Epidemiology, School of Public Health, Iran University of Medical Sciences, Tehran, [4]Amol Faculty of Paramedical Sciences, Mazandaran University of Medical Sciences, Sari, Iran *For correspondence: ssbarzegari@mazums.ac.ir

height and proximity to the volcanic mountains and the incidence of gastric cancer.

Materials and Methods

The study area

Ardabil province is located at 37º9'21"-39º42'32" northern geographical latitude and 47º1'51"-48º54'7" eastern geographical longitude bordering south side of Aras River, east and south of eastern Azerbaijan and west part of gilan province and Azerbaijan Republic. Ardabil province has the 23th rank among 34 provinces of Iran considering human development. As it can be seen in map 1, this province encompasses 17, 800 km2 including 10 towns and 537 villages. According to census in 2012, Ardabil is a province with population of 1.248 million and population density of 70 per km2 (Statistical center of Iran, 2012). The majority of the population (more than 98%) is of Azeri ethnicity.

Study design and study population

This is a cross-sectional descriptive study and the statistical population included all registered gastric cancer patients in Ardabil about 1056 patients within March 2003 to September 2011. The participants were collected using documents and files available in cancer registry center (Aras) in Ardabil Imam Khomeini hospital. Because of non-exact location address in some patient's files, we used 910 patient's information in statistical analysis of data and GIS maps.

Data collection and analysis

From documents and records in the cancer registry in Imam Khomeini Hospital of Ardabil necessary information such as gender, occupation, age and place of residence and the exact address location were extracted. Collected data analyzed by statistical methods in SPSS.19 and also in Arc view GIS 10 for presentation the distribution of cancer cases.

Statistical analysis

We obtained the Latitude and longitude location of each patient by Google earth and then transferred to the Arc view GIS 10.1 software. The hot spot and Spatial autocorrelation (Moran's I) was done for distribution of patients and classified the patients in Buffers with 10 km from Sabalan Volcano in height 400 m. The incidence of gastric cancer in different height and distance classes according to the population and patients of each class calculated by GIS software. We used linear regression analysis with the software package SPSS.19 for investigation the relationship between height, distance from the volcano, and other factors with incidence of gastric cancer.

Table 1. Incidence of Gastric Cancer by Residence Place in Cities

City	Population	Pop_R	Pop_U	Patient	Patient_R	Patient_U	Incidence	Inciden_R	Inciden_U
Ardabil	567361	61692	505669	352	173	179	0.62	2.804	0.353
Sarein	30188	11988	18200	28	24	4	0.927	2.002	0.219
Namin	70524	46316	24208	97	73	24	1.375	1.576	0.991
Germi	86820	53712	33108	90	71	19	1.036	2.144	0.573
BilaSuvar	51812	31336	20476	60	47	13	1.158	1.499	0.634
Meshgin	162980	89373	73607	129	97	32	0.791	1.085	0.434
Nir	25420	18800	6620	29	20	9	1.14	1.063	1.359
Kosar	29246	20670	8576	21	15	6	0.718	0.725	0.699
Khalkhal	106771	51760	55011	59	35	24	0.552	0.676	0.436
Parsabad	161115	68848	92267	45	30	15	0.279	0.435	0.162
All	1292237	454495	837742	910	585	325	0.704	1.287	0.387

Table 2. Distribution of Gastric Cancer by Altitude

	Altitude							
	0-400	800	1200	1600	2000	2400	2800	4800
Population	214400	61198	64399	764875	140344	15380	344	0
Pop_City	119168	25460	7055	593907	53408	0	0	0
Pop_Village	95232	35738	57344	170968	86936	15380	344	0
Patient	97	52	66	514	155	25	1	0
P_City	28	5	16	240	36	0	0	0
P_Village	69	47	50	274	119	25	1	0
Incidence	0.452	0.85	1.02	0.672	1.1	1.62	2.9	0
In_City	0.234	0.196	2.267	0.404	0.674	0	0	0
In_Village	0.724	1.315	0.871	1.602	1.368	1.625	2.906	0
Area	2552.1	1592.7	2285.7	5177.6	3403.9	714.2	223.2	176.3
Cardia_ Incidence	0.219	0.408	0.543	0.266	0.391	0.78	2.9	0
Fundus_ Incidence	0.21	0.343	0.357	0.31	0.463	0.78	2.9	0
Antrum_ Incidence	0.093	0.18	0.279	0.18	0.37	0.39	0	0

Results

Of all cases, 672(73.8%) were male and rest of them were female with sex ratio 3 to1. The incidence of gastric cancer by cities and residence place were in Table 1.
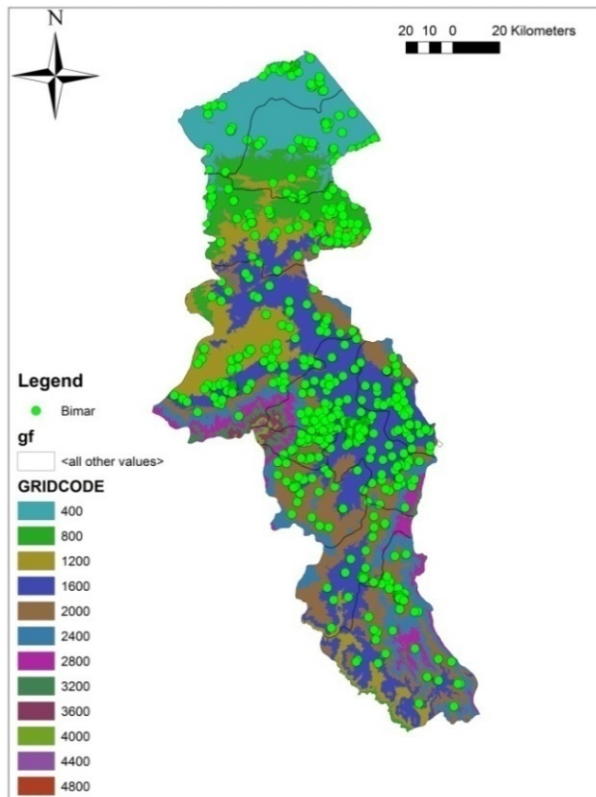

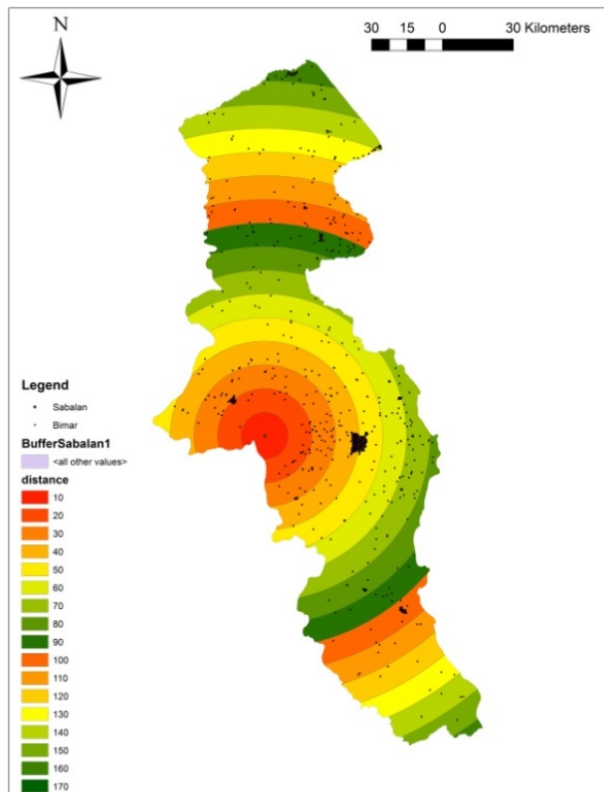**Figure 1. Distribution of Gastric Cancer by Altitude in Ardabil Province**

Figure 2. Distribution of Gastric Cancer by Distance From Sabalan Volcano in Ardabil Province

With replace cancer cases on Ardabil province elevation map (Figure 1) and produce the height classes in 400 m, the results were in Table 2. Also created a buffer of 10 kilometers of volcanic mountains and add descriptive data on the map (Figure 2), the result of table 3 was obtained.

The results of hot spot and Spatial autocorrelation (Moran's I) analysis by Arc GIS software is presented in Figures 3 and 4.

The hot spot and Spatial autocorrelation (Moran's I) analysis can be observe the regular and irregular of diseases in one location and the effect of factors on diseases. The map produced by GiZScore. The irregular and cluster distribution of gastric cancer in areas of the province of Ardabil. To extract some hidden data on the map and to improve understanding of map hot spots, IDW interpolation was used. (Figure 5)

The distribution of hot spots suggests that the closer to the volcano the people live the denser involvement with the cancer is observed. We used from linear regression method for study relationship between highest and GC
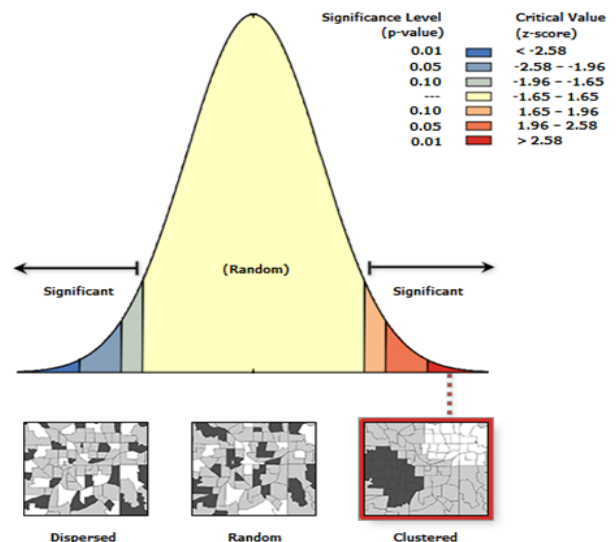

Figure 3. Spatial Autocorrelation (Moran's I) Analysis of GC in Ardabil Province
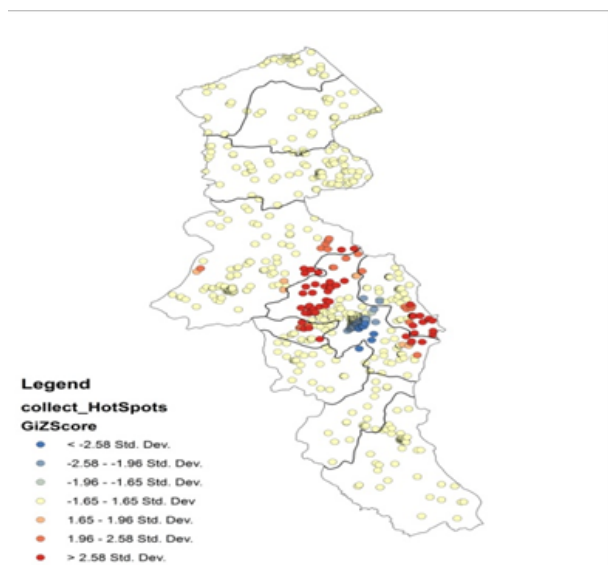

Figure 4. Hot Spot Analysis of GC in Ardabil

Table 3. Distribution of Gastric Cancer by Distance from Sabalan Volcano

Distance From Sabalan Volcano	10	20	30	40	50	60	70	80
Population	104	41644	133577	345992	243103	50783	52430	29558
Pop- City	0	26104	68945	297164	208871	17967	5922	7158
Pop_ Village	104	15540	64632	48828	34232	32816	46508	22400
Patient	0	38	138	176	119	78	86	25
Patient_ City	0	12	23	109	72	17	15	6
Patient_ Village	0	26	115	67	47	61	71	19
Incidence	0	0.912	1.033	0.508	0.489	1.535	1.64	0.845
In_City	0	0.459	0.333	0.366	0.344	0.946	2.532	0.838
In_Village	0	1.673	1.779	1.372	1.372	1.858	1.526	0.848
Cardia_ Incidence	0	0.384	0.389	0.19	0.213	0.649	0.762	0.202
Fundus_ Incidence	0	0.504	0.471	0.239	0.23	0.571	0.781	0.338
Antrum_ Incidence	0	0.216	0.254	0.124	0.123	0.472	0.534	0.372
Area	287.8	762	1236.3	1612.4	1653.4	1746.3	1583.9	1196.7
Distance From Sabalan Volcano	90	100	110	120	130	140	150	160
Population	61009	78993	26226	12296	31807	55111	27933	108352
Pop- City	31497	41165	4578	0	3875	25263	2797	88924
Pop_ Village	29512	37828	21648	12296	27932	29848	25136	19428
Patient	53	71	23	15	32	22	11	23
Patient_ City	19	22	2	0	4	9	2	13
Patient_ Village	34	49	21	15	28	13	9	10
Incidence	0.868	0.898	0.876	1.219	1.006	0.399	0.393	0.212
In_City	0.603	0.534	0.436	0	1.032	0.356	0.715	0.146
In_Village	1.152	1.295	0.97	1.219	1.002	0.435	0.358	0.514
Cardia_ Incidence	0.409	0.367	0.343	0.406	0.471	0.217	0.286	0.101
Fundus_ Incidence	0.278	0.303	0.381	0.569	0.534	0.181	0.178	0.101
Antrum_ Incidence	0.278	0.291	0.305	0.406	0.157	0.09	0	0.027
Area	1199.6	1208.5	1081	996.1	1119	1189.4	718.6	209

Table 4. Result's of linear regression Analysis

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	Std. Error	B	Beta		
Distance	0.076	-0.707	-0.286	-9.314	0
Altitude	2.229	2.292	0.031	1.028	0.304
Residence place	4.267	-130.646	-0.705	-30.618	0

incidence. The results showed that there was a significant indirect relationship between distance to Sabalan with GC incidence, means that proximity to the volcano Sabalan increases the incidence of gastric cancer. It was found that the rate of GC in people from rural areas significantly higher than people from Urban areas. (Table 4)

Discussion

In this study according table 3, the mean incidence rate in distance 70 km from Sabalan with 70 per 100000 significantly higher than distance 70-160 km from Sabalan with 64 per 100000 . (OR=0.8, P=0.0018)

Akan et al in a study showed that there was a significant relationship between cancer cases and environmental radioactivity. In this study, the higher GC incidence rate was seen in distance 50-70 km from Sabalan exactly around the Namin, Meshkinshahr and part of Ardabil which probably can be related to higher radiation of radioactive materials and volcanic soil type. The results show a high incidence of gastric cancer hypothesis in kilometers closer to Sabalan than longer distances can be
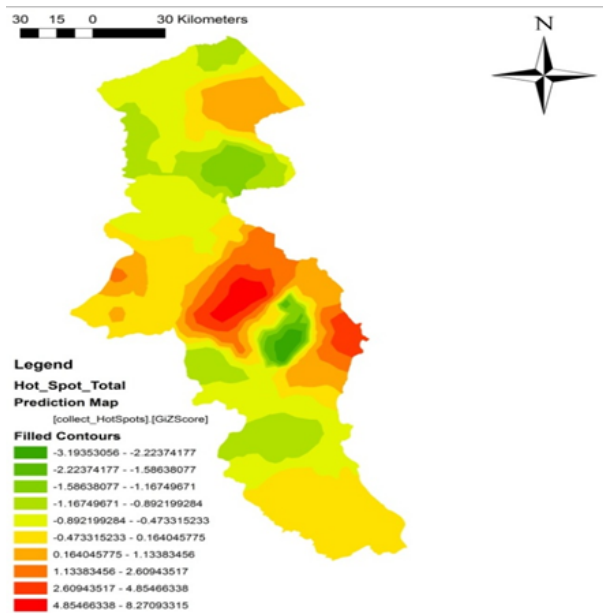
Figure 5. IDW Analysis of GC in Ardabil Province (Red dots indicate the hot spot areas and the blue dots indicate cold spots)

accepted (Akan et al., 2014).

In a study done in Chile about Urea nitrate and incidence rate of GC, results showed that despite the hypothesis that high nitrate due to stomach cancer, Nitrate concentration was higher in areas with a low risk of cancer which suggest the possibility of environmental cofactors involved in the conversion of nitrate to nitrosamine as a factor in gastric cancer. Also, in Chile study in the area with higher incidence rate the soil similar to soil of volcanic areas and contains high levels of Arsenic and low levels of selenium that could cause the conversion of nitrate to nitrous amines (Armijo et al., 1981).

Agustin et al in studies showed that more than 95% of countries with high level of digestive cancers, lymphoma, Leukemia and childhood cancers were in areas with radioactive materials and heavy metals such as copper, lead and cadmium (Amarel et al., 2006).

In our study, the rate of cancer in rural people was higher than urban people (64.3% v.s 35.7%) which weren't similar to other studies. These differences may represent the effect of other known or unknown environmental risk factors such as life style, agricultural poisoning and personal behaviors (Davoodabadi et al., 2003; Yazdanbod et al., 2007).

Of all cases, 73.8% were male and 26.2% were female and the sex ration 3 to 1 which was similar to other studies (Nourinayer et al., 2005; Yazdanbod et al., 2007). Also, in this study 42% of patients were farmer which was similar to other studies (Yazdanbod et al., 2007).

In our investigation 64.3% of patients were from rural, 80.9% Illiterate and 53.2% farmer and the rate of cancer incidence in low social economic levels were high which was similar to other study (Babaei et al., 2009; Ahari SS., 2013; Amorim et al., 2014).

The results of this study showed that the distribution of GC around the Sabalan volcanic mountain is significantly higher than other places in province, therefore, we can accept the hypothesis of increased incidence of gastric cancer in areas near the volcanic mountain. But the influence of other risk factors such as smoking and lifestyle should not be ignored.

Acknowledgements

References

Akan Z, Baskurt B, Asliyuksek H, et al (2014). Environmental radioactivity and high incidence rates of stomach and esophagus cancer in the Van Lake region: a causal relationship? *Asian Pac J Cancer Prev*, **15**, 375-80.

Amarel A, Rodirgues V, Oliveria J, et al (2006). Chronic exposure to volcanic environments and cancer incidence in the Azores, Portugal. *Sci Total Environ*, **37**, 123-8.

Amorim CA, Moreira JP, Rial L, Carneiro AJ, Fogaça HS, Elia C, et al (2014). Ecological study of gastric cancer in Brazil: Geographic and time trend analysis. *World J Gastroenterol*, **20**, 5036-44.

Armijo R, Gonzalez A, Orellana M, Coulson AH, Sayre JW, Detels R (1981). Epidemiology of gastric cancer in chile: Nitrate exposures and stomach cancer frequency. *In J Epidemiol*, **10**, 57-62.

Babaei M, Pourfarzi F, Yazdanbod A, et al (2010). Gastric cancer in Ardabil, Iran - a review and update on cancer registry data. *Asian Pac J Cancer Preve*, **11**, 595-9.

Davood Abadi AH, Sharifi H, Erfan N, Dianati M, Abdol Rahim Kashi E (2003). AN Epidemiologic and clinical survey on gastric cancer patients refered to shahid beheshti hospital of Kashan (1994-2001). *IJMS*, **34**, 211-22.

Dogan Nasır Binici, Timur Koca, Hakan Dursun (2009). Dietary habits, demographical, and socio-economical risk factors of the newly diagnosed gastric cancers in the eastern anatolia region of turkey: an endemic upper gastrointestinal cancer region. *Dig Dis Sci*, **54**, 2629-33.

Ferlay J, Soerjomataram I, Ervik M, et al (2013). GLOBOCAN 2012 v1.0, cancer incidence and mortality worldwide: iarc cancer base No. 11 [Internet]. Lyon, france: international agency for research on cancer. Available from http://globocan.iarc.fr.

Javier Torres, Pelayo Correa, Catterina Ferreccio, et al (2013). Gastric cancer incidence and mortality is associated with altitude in the mountainous regions of pacific latin America. *Cancer Causes Control*, **24**, 249-56.

Jesiis Vloque, Cayetano Merino Egea, Miquel Porta (1995). Stomach cancer mortality in Spain: an ecological analysis of diet, altitude, latitude, and income. *J Epidemiol Community Health*, **49**, 441-2.

Junko Ueda, Masahiko Gosho, Yoshikatsu Inui, et al (2014). Prevalence of helicobacter pylori infection by birth year and geographic area in Japan. *Helicobacter*, **19**, 105-10

Kasper DL, Braunwald E, Hauser S (2005). Harrison's principles of internal medicine. 16th ed. Mcgraw-Hill: London; **2005**, 523-32.

Kavousi A, Bashiri Y, Mehrabi Y, Etemad K, Teymourpour A (2014). Identifying high-risk clusters of gastric cancer incidence in Iran, 2004 - 9. *Asian Pac J Cancer Prev*, **15**, 10335-7.

Masoud Babaei, Hamid Jaffarzadeh, Malekzadeh Reza, et al

(2009).cancer incidence and mortality in Ardabil: The first report of angoing population based cancer registry in Iran. *Iranian J Public Health*, **38**, 35-45.

Nourinayer B, Akhondi Sh, Asadzadeh H, et al (2005). Evaluation of gastric cancer related indicators in Tehran and 7 other provinces in, 1999 and 2000. *Med Sci J Islamic Azad University*, **15**, 15-18.

Rahman R, Asombang AW, Ibdah JA (2014). Characteristics of gastric cancer in Asia. *World J Gastroenterol*, **28**, 4483-90.

Sadjadi A, Makekzadeh R, Derakhshani M, Sepehr A, Nouraei M, et al (2003). Cancer occurrence in ardabil: results of a population-based cancer registry from Iran. *Int J Cancer*, **107**, 113-18.

Sadeghiyeh-Ahari S, Agdam FB, Amani F, Yazdanbod A, Akhghari L (2013). Analysis of the relationships between esophageal cancer cases and climatic factors using a Geographic Information System (GIS): a case study of Ardabil province in Iran. *Asian Pac J Cancer Prev*, **14**, 2071-7.

Yazdanbod A, Malekzadeh R (2007). Epidemiology of upper gastro intestinal Cancers in Iran: A subsite Analysis of 767 cases. *World J Gastroenterol*, **13**, 5367-70.