RESEARCH ARTICLE

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

Saeid Sadeghieh Ahari[1], Fridoon Babaei Agdam[2], Firouz Amani[3]*, Abbas Yazdanbod[4], Leyla Akhghari[5]

Abstract

Esophageal cancer is a mjaor health problems in many parts of the world. 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 esophageal cancer and effective climatic factors using GIS. The dispersion distribution and the relationship between environmental factors effective on cancer were measured using Arc GIS. The highest degree of spread was in Germi town and the least was in Ardabil city. There was a significant relationship between effective environmental factors and esophageal cancer in Ardabil province. The results indicated that environmental factors probably are influential in determining the incidence of esophageal cancer. Also, these results can be considered as a window to future comprehensive research on esophageal cancer and related risk factors.

Keywords: Environmental factors - esophageal cancer - geographic information system - risk factor

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Introduction

There is a growing worldwide concern for esophageal cancer because it has been fixed in frequency in 30 years past (Pierre et al., 2012). Nearly 482,300 new cases of esophageal cancer and 406,800 deaths from esophageal cancer have been reported occurring during 2008 all over the world (Ahmedin et al., 2011). In spite of the drop in the number of gastric cancer occurrences globally, it persists to be a serious problem in Iran, although the occurrence frequency varies internationally (Mousavi, 2009).

With respect to this point that 16-fold (Ahmedin Jemal et al., 2011; Pedram et al., 2011) occurrence range of esophageal cancer is from 3/100,000 people per year in the U.S. white population to >100/100,000 people per year in some areas of China (Kamangar et al., 2007), it currently ranks second and third malignancy among Iran males and females, respectively (Sadjadi et al., 2010).

Ardabil province, a mountainous land, is located in the north west of Iran and has an area of 18,011 km^2 with a population of 1.6 million persons, where 46% of people live in urban areas (Figures 1 and 2) (Sadjadi et al., 2009). Upper gastrointestinal cancer is the most widespread cancer in Ardabil Province, accounting for more than 50% of deaths from cancer in this region which indicates the lower probability of recovery (Samadi et al., 2007).

The incidence rate of esophageal cancer in Ardabil has the second rank in Iran country after Golestan province (Kamangar et al., 2007) (Table 2). The spread of esophageal cancer has been investigated in different aspects and regarding obvious changes in esophageal cancer frequency in different parts of the world, the exact analysis of esophageal cancer by geographical distribution

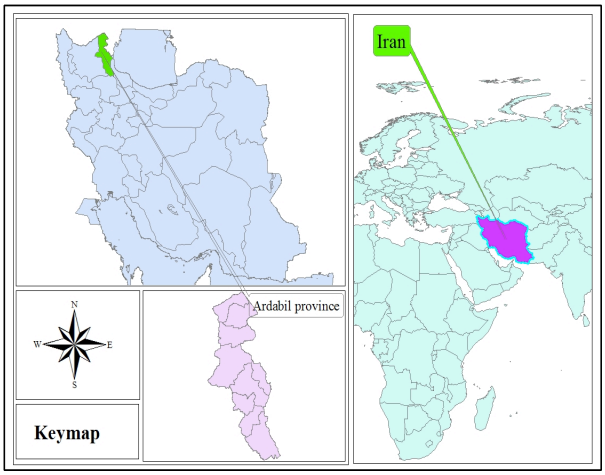

Figure 1. Geographical Location of Case Study

*[1]Community Medicine, [3]Biostatistics, [4]Gastroenterology, [5]General Practitioner, Ardabil University of Medical Science, [2]Geography Department, University of Mohaghegh Ardabili, Ardabil, Iran *For correspondence: f.amani@arums.ac.ir*

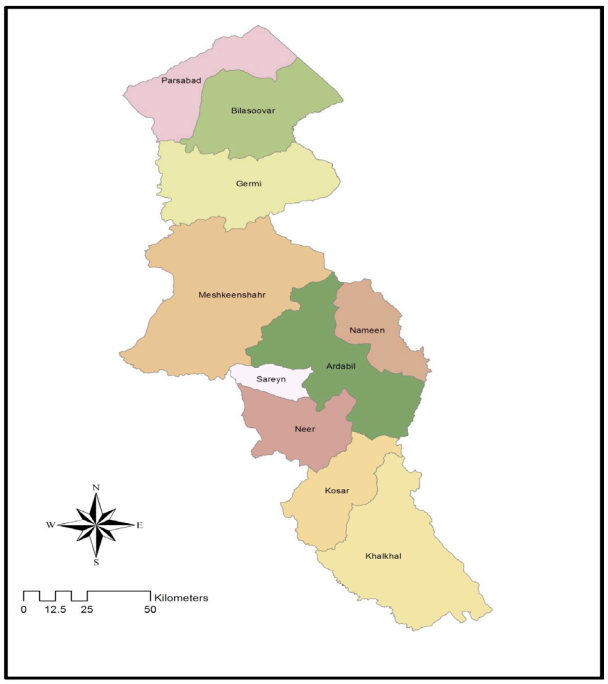

Figure 2. Administrative Map of Ardabil Province

Table 1. The Comparison of the Age Standardized Rates (ASR) for Selected Provinces of Iran

Province	ASR for Male/100000	ASR for Female/100000
Golestan	43.3	36.3
Ardabil	15.4	14.4
Semnan	11.7	8.8
Kerman	3.0	2.1
Iran(overall)	17.6	14.4

seems to be helpful. GIS provides the possibility of investigating diseases special patterns for epidemiologists and cancer researchers in order to find out the relationship between cancer and other variables related to health, social-economic, and environmental issues (Brewer, 2006).

The cancer is the disease that can be originated from environmental factors. The limited studies have been done based on the relationship between climatic factors and different kinds of cancer (Diffey, 2004; Wu, 2007) and this relationship has been under serious question in some studies (Ke, 2002). The present study attempts to analyze the relationship between cancer incidence distribution and climatic factors in Ardabil province. To this end, the collected data are combined in special frames using GIS and Remote Sensing (RS), then geo-statistical maps indicating cancer density in towns were provided using statistics related to 2003-2011. Therefore, esophageal cancer distribution map was designed with regard to the population and climatic factors.

Materials and Methods

Cancer registry in IRAN and Ardabil province

Regular report submission on cancer in Iran was commenced in 1955 (Etemadi et al., 2008). Observations proved high incidence of esophageal cancer in the Caspian Littoral in 1969 leading to establishment of the first population-based cancer registry with joint effort of University of Tehran and the International Agency for Research on Cancer (IARC) in Babol city (Kmet and Mahboubi, 1972; Etemadi et al., 2008).

In 1998, Tehran Population-Based Cancer Registry (TPBCR), or named Tehran

Metropolitan Area Cancer Registry (TMACR), was started (Mosavi-Jarrahi et al., 2007). In addition, Digestive Disease Research Center (DDRC) was established in Tehran University of Medical sciences in 1992 (Etemadi et al., 2008). On the other hand, new branches of population-based cancer registry were established in Northern Iran by DDRC in cooperation with IARC, Center for Disease Control in Iranian Ministry of Health and local medical sciences universities. Consequently, The Ardabil Cancer Registry office is managed presently by Ardabil University of Medical Sciences under the supervision of the DDRC, and it has been IACR member since 2005 (Etemadi et al., 2008).

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 republic of Azerbaijan. Ardabil province has the 23th rank among 30 provinces of Iran considering human development (Pourtalei, 2011). As it can be seen in map 1, this province encompasses 17,800 km^2 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 km^2 (Statistical center of Iran, 2012).

Study population

The statistical population included all esophageal cancer patients in Ardabil province 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. The sample comprised 661 esophageal cancer patients.

Data collection instrument and procedure

Using documents and files available in cancer registry center (Aras) in Ardabil Imam Khomeini hospital, the necessary information such as age, gender, birthplace, address, job, marital status, risk factors affecting the disease (cigarette, alcohol, and opium), tumor type, anatomy of involved part, education degree, clinical symptoms, and family background were extracted. This information was classified and entered into Excel software. The collected data were analyzed by descriptive and analytical statistical methods such as table, graph and chi-square test in SPSS software.

Also, a part of above-mentioned information was encoded and entered into Arc-GIS 10. Afterwards, the maps of Ardabil province illustrating dispersion of the patients suffering esophageal cancer with regard to address, gender, job, risk factor, and tumor type were

provided.

GIS analysis

In order to analyze the data spatially, ARCGIS 10 was used. The basis for computation of geographical width and longitude in coordinate systems applied (UTM zone 39) in all data is datum WGS -1984. The information related to administrative units was extracted from maps of Ardabil province with 1:50000 scale. Also, the population-based data of administrative units have been received from census in 2007.

After specifying geographical coordinates of every patient and matching it with data from administrative units, their situations were drawn on geo-referenced maps. Climatic data were obtained from 4 synoptic stations including Ardabil, Pars Abad, Meshkin Shahr, and Khalkhal. These data led to creation of interpolated maps of climatological elements like temperature, precipitation, humidity, and sun hours. To investigate the relationship between these elements and cancer incidence, the intersect order available in ArcGIS software was used.

Moral considerations

This cross-sectional descriptive study was approved by the Research Board of Ardabil University of Medical Sciences. Considering this point that this research has been done based on recorded information in Ardabil cancer registry and there was no intervening activity, there is no special moral consideration and all data were kept confidential.

Results

Among 161 patients with Esophageal cancer, 430 people were men (65.1%) and 231 people were women (34.9%). The degree of cancer development among men was 1.9 times higher than women which was statistically significant (p=0.0001). 281 cases were urban (42.5%) and 380 cases were rural (57.5%). The degree of cancer development in rural areas was 1.4 times more than urban areas which was statistically significant (p=0.0001). 522 people (79%) were married. 522 patients (83.5%) were illiterate.

After locating cancer incidence cases, their distribution was established based on town divisions. Therefore, cancer distribution map has been provided in order to visualize the frequency of cancer incidence (Figure 3). Figure 3 and population statistics of towns in Ardabil province indicate that areas with high population show higher frequency of cancer incidence so that this cannot be appropriate index to analyze the disease spatially. As a result, the cancer incidence index was used for this purpose.

The cancer incidence index

The cancer rates in towns of Ardabil province have been computed as an instrument to make a comparison among regions and analyze statistically. With the knowledge about the number of patients separated by towns and population-based statistics based on the recent population and housing census (2006), this index was

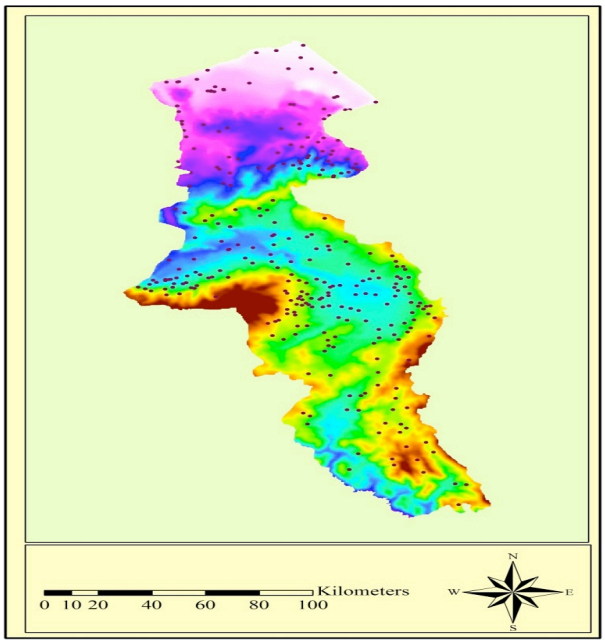

Figure 3. Geographical Distribution of Esophageal Cancer in Ardabil Province

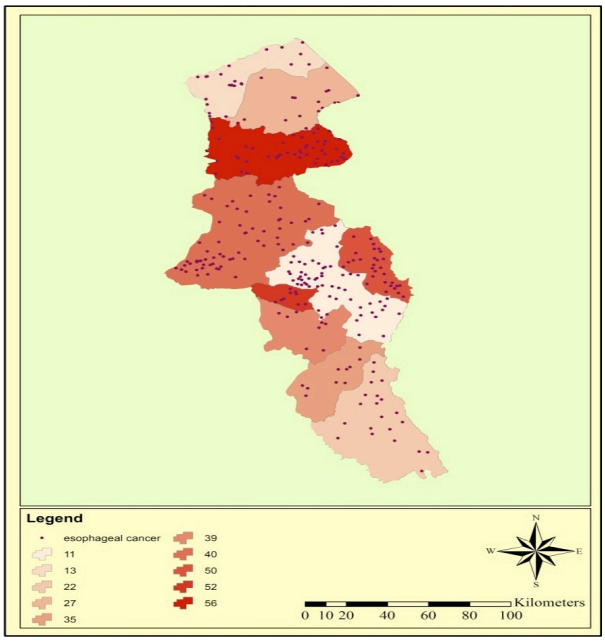

Figure 4. Incidence Rates According Administrative Units

Table 2. Incidence Rates According Administrative Units

Town	Population	Area	Cases	Incidence
Ardabil	531514	2218	58	11
Parsabad	164577	1395	22	13
khalkhal	95005	2691	21	22
Bilasoovar	55026	1782	15	27
Kosar	28721	1260	10	35
Neer	23035	1195	9	39
Meshkeenshahr	159242	3719	64	40
Nameen	59640	940	30	50
Sareyn	17318	373	9	52
Germi	91270	2055	51	56
Total	1067336	17629	588	34.5

computed.

Figure 4 and Table 2 indicate cancer occurrence frequency all over 10 administrative unites of Ardabil province. Administrative units with more than 40 cancer density, dark brown shaded areas on the map, are considered to be risky regions. Therefore, 4 administrative units have a high occurrence rate of cancer. The occurrence frequency in Ardabil province was calculated to be 34.5 suggesting the fact that the cancer incidence rate in this province is generally higher than the correspondent rate estimated by WHO for developing countries.

Relationship between the esophageal cancer cases and climatic elements

In order to investigate the relationship between cancer incidence and climatic elements considered in this research, the cancer distribution map based on these indices were provided. Regarding low number of stations for measuring climatic elements in the studied area, the maps have been designed using Inverse distance weighting (IDW) interpolation approach. In next stage, frequency of esophageal cancer incidence was computed in different classes of 4 elements utilizing intersect instrument. Also, analyzing the relationship between cancer incidence and these elements obligated the use of Pearson chi-square and the obtained results can be seen in Table 4.

Table 3. The Distribution of Climatic Factors (Temperature, Precipitation, and Humidity)

Climatologic factor	Cancer Freq.		Maximum Value	Maximum Freq.	Minimum Value	Minimum Freq.
Temperature(Centigrade)						
7-11	373	(63.4%)	10	212	21	2
12-16	149	(25.3%)				
17-21	66	(11.2%)				
Precipitation(Millimeter)						
245–275	62	(10.5%)	350-336	178	381-394	18
276–305	110	(18.7%)				
306–335	175	(29.8%)				
336–365	196	(33.3%)				
366–394	45	(7.6%)				
Humidity(Percent)						
58–61	152	(25.5%)	63-62	144	71-70	25
62–65	249	(42.3%)				
66–69	130	(22.1%)				
70–73	57	(9.7%)				
Sunshine(Hours)						
2247–2417	206	(35.0%)	2503-2587	171	2758-2842	7
2418–2587	267	(45.4%)				
2588–2757	61	(10.4%)				
2758–2928	20	(3.4%)				
2929–3102	34	(5.8%)				
Total	588	(100%)				

Table 4. Statistical Result of Relationships between Climatic Factors and Esophageal Cancer

Factor	X^2	df	p
Temperature	81.113	14	0
Precipitation	241.063	157	0
Humidity	44.330	16	0
Sunshine hours	895.853	836	0

The investigation of classified maps related to climatic elements suggests an important point. Due to lack of balance in geographical distribution of populated centers in Ardabil province and role of Ardabil city in formation of the phenomenon named urban primacy in urban hierarchy of the province, the analysis of relationship between environmental elements especially climatic elements and esophageal cancer incidence is open to challenge. So this can be considered as the most important reason for the entropy in the relationship between these variables and dependent variables of the research. In other words,

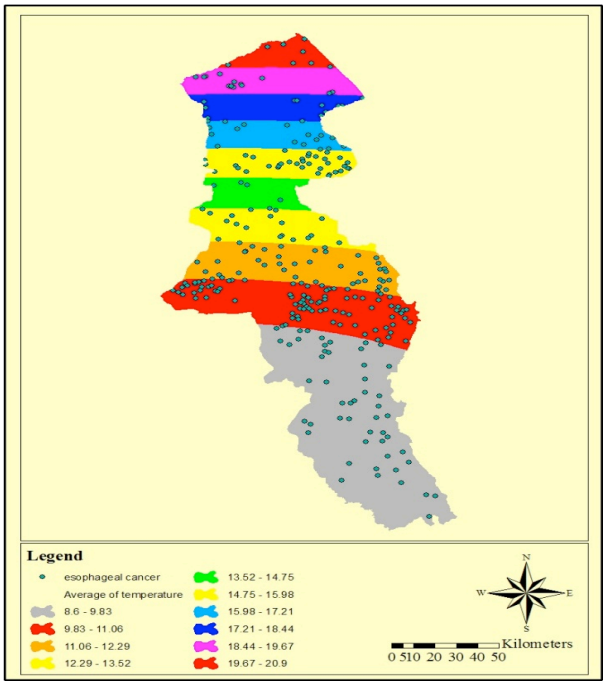

Figure 5. The distribution Map of Esophageal Cancer Based on Temperature

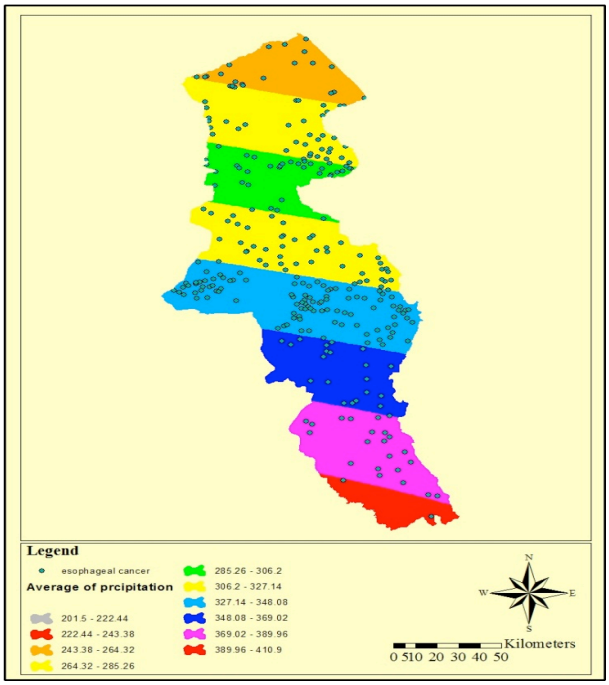

Figure 6. The Distribution Map of Cancer Cases Based on Precipitation

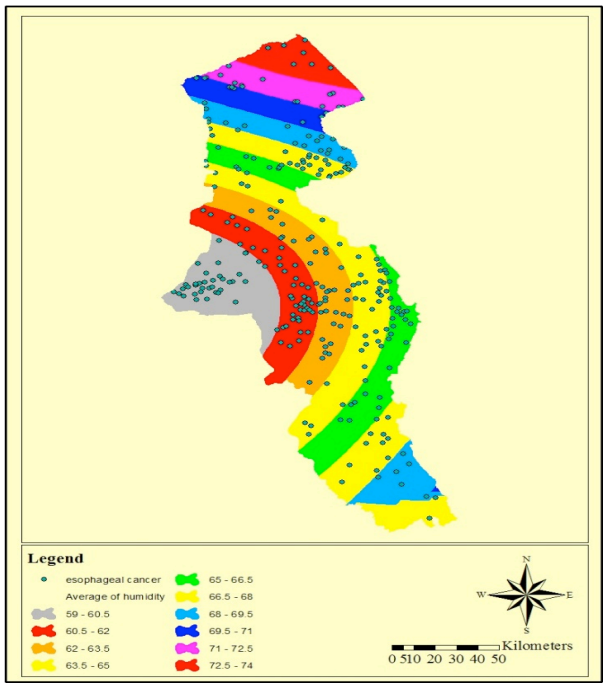

Figure 7. The Distribution Map of Cancer Cases Based on Humidity

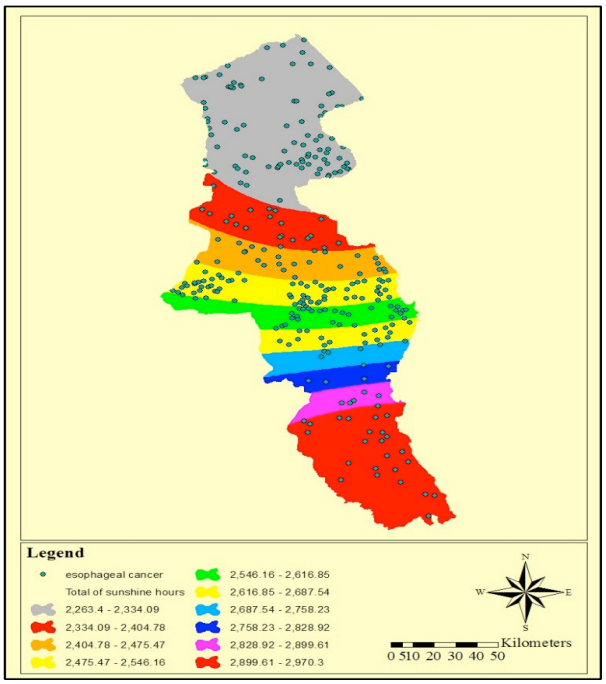

Figure 8. The Distribution Map of Esophageal Cancer Based on Sunshine Hours

placing Ardabil city in each class of climatic elements gives nonlinear condition to the relationship between variables considered at the present study. To solve this problem, this factor can be considered during the statistical analysis.

Temperature

Map 5 illustrates the geographical distribution of cancer incidence cases in each temperature class of Ardabil province. The highest incidence rate of cancer (63.4%) has been observed in range of 7-11 centigrade. Also 12-16 and 17-21 ranges have indicated 25.3% and 11.2%, respectively (Table 3). The regions with average temperature (10 centigrade) have shown the highest esophageal cancer incidence. Therefore, the increase in temperature indicated less cancer cases. On the other hand, the results obtained from chi-square yields X^2=81.113, df=14, p=0.000 (Table 4). It can be concluded that there is a significant relationship between temperature and esophageal cancer incidence in Ardabil province.

Precipitation

Geographical distribution of esophageal cancer in precipitation classes of the studied area can be seen in map 6. Regions with annual rainfall of 336-365 ml have reflected the most cancer incidence cases (33.3%). While the areas with amplest rainfall (7.6%) have been reported to have the lowest number of cancer incidence. So it can be concluded that regions with rainfall less or more than 300-365 precipitation range have the least incidence. Therefore, it can be inferred that the increase in rainfall to 365 ml leads to increase the number of cancer incidences and then this number is decreased. The results pertained to chi square analysis yields X^2=241.063, df=157, p=0.000 (Table 4). All these indicate that there is a significant relationship between temperature and esophageal cancer incidence in Ardabil province.

Humidity

The investigation of esophageal cancer incidence distribution in relative humidity category of Ardabil province (map 7) and special condition of urban hierarchy of Ardabil province lead to reason that increase in relative humidity causes decrease in the number of cancer incidences. In other words, the largest number of incidences has been reported in regions with least humidity. The maximum of cancer prevalence can be observed in regions with 62.5% humidity and minimum prevalence can be observed in regions with over 70% humidity. The results of Chi square analysis yields X^2=44.330, df=16, p=0.000 which reveals that the relationship between humidity and esophageal cancer incidence in Ardabil province is significant (Table 4).

Sunshine hours

The geographical distribution of esophageal cancer in sunshine hours' classes of Ardabil province has been illustrated in map 8. The regions with annually 2500-2600 sunny hours have been reported to include the highest cancer incidence cases. Unlike, the regions with annually 2750-2850 sunny hours have the lowest cancer incidence cases. It can be concluded that regions with more sunshine hours have more cancer incidence. In other words, the increase in the received sun shines leads to a decrease in cancer incidence. Results obtained from Chi square analysis yields X^2=895.853, df=836, p=0.074 (Table 4). These Figures and Table 4 as well as map 7 reveal that there is a significant relationship between sun shine and esophageal cancer incidence in Ardabil province.

Discussion

Esophageal cancer is one of the most frequent cancers worldwide, but its geographic distribution is disparate (Pedram et al., 2011). 51,000 new cancer

cases are observed annually in Iran country including 38% gastrointestinal cancer and 6,500 cases belong to esophageal cancer (Sadjadi et al., 2005). Esophageal cancer incidence in Ardabil Province includes 34.5% of one thousand people and has the second rank after Golestan Province (Sadjadi et al., 2010). According to division of ten towns of Ardabil Province, the most incidences have been reported in Germi town (56% of one thousand people) and least incidences occurred in Ardabil town (11% of one thousand people). Ardabil town as the center of Ardabil province enjoys the highest social and economical indices but Germi town is one of those towns that has the least social and economical factors. This point that the decrease in esophageal cancer incidence happens along with improvement of social and economical indices and life conditions is consistent with results of the other studies done both in Iran and other countries worldwide (Semnani et al., 2006; Sadjadi et al., 2010).

Regarding different risk factors influencing esophageal cancer such as having hot tea, unhealthy water, grilled meat, opium, alcohol, cigarette, the dispersion of these factors in the province can affect this issue (Sadjadi et al., 2010).

The investigation of esophageal cancer distribution and comparing it with Province map considering the temperature indicates the high frequency of esophageal cancer (63.4%) in 7º-11º range so that the increase in temperature leads to the decrease in esophageal cancer frequency. Through interpretation of these results, it can be suggested that higher temperature highly necessitates the use of refrigerator which affect food preservation. Also, in regions with lower temperature, one method of meat preservation is more common in which the meat is fried and kept in pottery for a long time to be consumed gradually which probably accelerates esophageal cancer incidence so that some studies have proved that use of such meat with 8 adjusted odds ratio were leading factor in esophageal cancer (Sadjadi et al., 2010).

However, these findings do not echo those of Miller that indicated a direct relationship between region temperature and esophageal cancer incidence (Miller, 2001).

The investigation of esophageal cancer distribution and comparing it with Province map considering annual rainfall revealed high frequency of esophageal cancer in regions with 336-365 ml annual rainfall. Esophageal cancer frequency is increased when there is ample rainfall in the given area. The interpretation of these results proposes this probable factor that high rainfall may lead to some changes in life style, development of husbandry industry, planted products, use of fertilizers, and preservation of some products like wheat and allow for esophageal cancer incidence in great numbers. In addition to rainfall, leaching causes an increase in nitrate within surface waters and agricultural products which can be considered as another reason for cancer incidence (Keshavarzi et al., 2012). In a previous study, increasingly esophageal cancer in regions with higher rainfall has been referred to increase in fumonisim – a type of mycotoxin produced by Fusarium verticillioides which is one of probable carcinogens of esophageal cancer – which confirms findings of present research (Miller, 2001). Death-leading esophageal cancer in regions with high rainfall has been confirmed in the studies previously done in China (Wu, 2007). Meanwhile, China and northern regions of Iran are located within Silk Road and high esophageal cancer incidence can be observed along this road. This geographical distribution along the road involving both Mongol and Turk race advocates the effect of race factors and climatic conditions (Kamangar et al., 2007).

The investigation of esophageal cancer distribution map and the comparison with Province map considering humidity proposes high frequency of esophageal cancer in regions displaying 62-65% humidity. There is no correlation between esophageal cancer frequency and humidity. In order to interpret the results, the discussed issues on rainfall can be referred.

The investigation of esophageal cancer distribution map compared to Province map considering sun shine hours indicate that increase in sunshine hours makes a decrease in the frequency of esophageal cancer. The increase in sunshine hours and consequently absorption of vitamin D play a main role in the reduction. Recent ecological observations have revealed evidences on the effect of solar ultraviolet-B and vitamin D on the decrease in esophageal cancer (Launoy et al., 1998; Lappe et al., 2007). Sunless days and less absorbed vitamin D in Ardabil Province, known as a cold region which forces the people to be confined to indoors in most time of year, can be one of reasons for high incidence rate of esophageal cancer.

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