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The Spatial Distribution of Cancer Incidence in Fars Province: A GIS-Based Analysis of Cancer Registry Data

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Original Article

ABSTRACT

Background: Cancer is a major health problem in the developing countries. Variations of its incidence rate among geographical areas are due to various contributing factors. This study was performed to assess the spatial patterns of cancer incidence in the Fars Province, based on cancer registry data and to determine geographical clusters.

Methods: In this cross sectional study, the new cases of cancer were recorded from 2001 to 2009. Crude incidence rate was estimated based on age groups and sex in the counties of the Fars Province. Age-standardized incidence rates (ASR) per 100,000 was calculated in each year. Spatial autocorrelation analysis was performed in measuring the geographic patterns and clusters using geographic information system (GIS). Also, comparisons were made between ASRs in each county.

Results: A total of 28,411 new cases were diagnosed with cancer during 2001-2009 in the Fars Province, 55.5% of which were men. The average age was 61.6 ± 0.5 years. The highest ASR was observed in Shiraz, which is the largest county in Fars. The Moran's Index of cancer was significantly clustered in 2004, 2005, and 2006 in total, men, and women. The type of spatial clustering was high-high cluster, that to indicate from north-west to south-east of Fars Province.

Conclusions: Analysis of the spatial distribution of cancer shows significant differences from year to year and between different areas. However, a clear spatial autocorrelation is observed, which can be of great interest and importance to researchers for future epidemiological studies, and to policymakers for applying preventive measures.

Keywords: Cancer, Iran, spatial analysis

INTRODUCTION

Today, cancer is one of the most important health problems in the world, causing concerns for healthcare systems. Cancers cause high morbidity and mortality.[1,2] New cases of cancer are ever-increasing worldwide, and more than half of the cases are from low and middle income countries.[3,4] Increased exposure to a variety of risk factors and social inequalities are expected to increase the absolute number of cancer cases and their consequences so that an increase of 35% of new cases is predicted in 2020.[3-5]

In developing countries, lack of equal access to healthcare services and community status, adoption of western lifestyle, and increased old age have led that the burden of cancer has changed during recent decades, and Iran is not an exemption from these conditions.[6,7]

Annually, almost 50,000 new cases occur in the Iranian population.[8] Cancer, is the third most common cause of death in Iran after cardiovascular diseases and car accidents.[9-12] It is estimated that annually 35,000 deaths are due to cancer. Sadjadi *et al.*, report that Iran is the second country based on mortality rate due to cancer in Eastern Mediterranean region of world health organization (WHO).[6]

In order to control and reduce morbidity and mortality of cancer and also to carry epidemiological studies, geographical distribution of cancer should be determined as a first step.[12] Researchers have demonstrated that a strong link exists between health status and areas where people live in.[1,8] The characteristics of an area such as, industrial environment, climate, socioeconomic status, lifestyle, and racial groups have a strong effect on cancer incidence and health outcomes.[1-3,8,9]

Geographic information system (GIS) is a computer-based system and a potentially powerful assessment tool to represent health data in a visual format by linking statistical and thematic data on maps. It can play a prominent role in helping public health authorities and policy makers for decision-making and planning in epidemiological studies.[13-16] A review of published literature shows that many studies have been conducted on cancer assessment by using GIS in countries.[1,2,17,18]

In Iran, most of existing literature in this context is on epidemiological studies that have not used spatiotemporal techniques.[9,11,12,19] Only a few studies have documented evaluation of geographical variation of cancer incidence by applying GIS.[8,20,21]

This article aims to map the cancer incidence in the counties of Fars Province, and also to explore the spatial pattern trends or changes of disease during the years 2001-2009.

METHODS

This study was carried out in Fars Province, which is located in southern Iran and has an area of about 122,400 km^2 which is at 27°31’ to 31°42’ longitude north and 50°37, to 55°38’ latitude east.[22] The total population of Fars is about 4.6 million and male to female ratio is 1.03.[23] The administrative divisions in 2010 included 24 counties. The capital city is Shiraz, one of the metropolises in Iran [Figure 1].

In this cross sectional study, we used map data, population distribution derived from census and patient data. The new cases were patients diagnosed with cancer whom are registered between 2001 and 2009 among the study population in the Cancer Registry Center of Shiraz University of Medical Sciences. This center use multiple sources (hospital, diagnostic facilities, and death certification); the data were collected from throughout the Province and then to be set up in Deputy of Health at Shiraz University of Medical Sciences (Cancer Registry office). Also, these were checked by the Ministry of Health, and then to be sent to this center in Shiraz.

The reports were based on pathology laboratories. Data sheet included 33,398 patient names, sex, age at the time of diagnosis, place of residence, and cancer diagnosis that was based on the international classification of disease for oncology (ICD-O).[24] The documents were checked and any duplicates cases with the same information, cases from the other provinces, unclear diagnosis, and uncertain address were excluded. The final data were summarized in another sheet and included 28,411 new cases and consisted of sex, place of residence, types of cancers, and an eight age-group classification.[25]

Crude incidence ratio was calculated for each sex and age groups in counties in each year. Then, to compare different counties, age-standardized rate (ASR) was calculated using standard world population.[26]

The calculated ASRs were transferred to the GIS software (Arc GIS 9.3), and mapping tools of GIS were then used for visualizing ASR for each year.[27]

We also used exploratory spatial data analysis (ESDA) to determine distribution pattern of cancer for each year of data.[28] One of the most frequently used methods is Moran’s Index, which evaluates local clustering or spatial autocorrelation

Figure 1: Map of counties of Fars province

by computing the contribution of each location to the Moran's I statistics for the whole study area.[28,29] Moran's I is a weighted correlation coefficient that takes values in the range (–1, 1). If value of Moran's I is a significant positive value, it indicates positive spatial autocorrelation, which means, a distribution pattern for counties having ASR similar to their neighboring counties. A significant negative value is negative spatial autocorrelation, meaning there is no similarity between neighbors.[28,30]

Moreover, we used the local indicators of spatial association (LISAs) measure in positive Moran's I, to identify meaningful spatial clusters ($P = 0.05$). LISA analysis was typically mapped to indicate counties with similar ASR (High, Low) among various areas.[28,31]

ASR calculation was performed in Microsoft Excel, spatial and temporal analyses were performed using Arc GIS 9.3™ and Geoda 1.0.1™.

RESULTS

A total of 28,411 new cases were diagnosed with cancer in 2001-2009 in Fars, 15,759 (55.5%) of which were men. The average age of cases was 61.6 ± 0.5 year, and it breaks down to 63.8 ± 0.6 for men and 58.8 ± 0.8 for women.

The averages ASR were 102.17 and 82.17 per 100,000 among men and women, respectively. The highest ASR among men was 148.82 per 100,000, observed in 2007, whereas for women, the highest value was 114.80 per 100,000 in 2009 [Figure 2].

Table 1 shows ASR in counties of Fars province that the highest value is Shiraz among all years.

To illustrate the geography of cancer, ASR distribution of the study region is plotted in Figure 3. Darker brown signifies a higher ASR value, and the men to women ratio for cancer is also symbolized in Figure 3. It is clear that in most of the counties, cancer incidence was more in men than women for various years, but the proportion of women has increased in 2009. It can also be observed that ASR showed a much dispersed distribution pattern in 2001 with three areas of high concentration, namely Shiraz, Marvdasht (northern Fars), and Larestan (southern Fars) in the following years (except 2002). The scattering was much less and the proportion of each cities increased, but consistently Shiraz, Marvdasht, and Larestan had a high density in each year. In 2002, ASR decreased throughout the Province.

These findings are supported numerically using Moran's I, shown in Table 2, where it is seen that in 2001 Moran's I is negative, meaning that pattern of cancer incidence was dispersed. The spatial distribution tends to cluster in subsequent years, and Moran's I becomes significant positive for three consecutive years (2004, 2005, and 2006) as shown with the *P* value. However, Moran's I decreased again and the distribution changed to a clustered pattern in the end of the period.

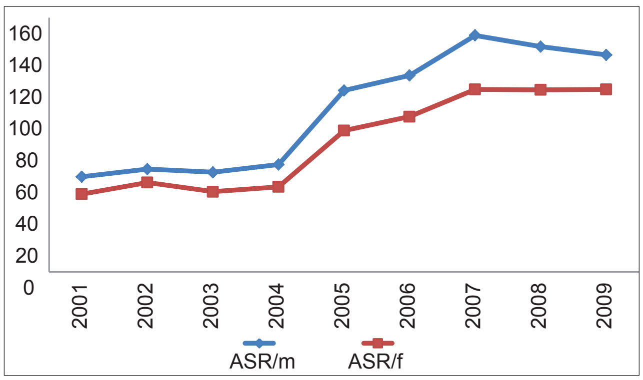

Figure 2: Age-standardized rate in men and women in Fars province, Iran, during 2001-2009

Geoda software was utilized to determine significant spatial clusters in certain years. The findings were showed high-high cluster on Shiraz, Sepidan, Mamasani, Nayriz, Arsanjan, Khorrambid, Bavanat, and ZarrinDasht that represent high ASRs are surrounded by those which also have high ASR.

Figure 4 shows spatial dependency of ASR in the men from 2001 to 2009. Cancer incidence was dispersed in the first year (Moran's I = −0.002 and −0.006) and in 2004, 2005, and 2006 had significant Moran's I and spatial clusters, while distribution pattern of cancer was diffuse in the next years. Counties with similar ASR were geographically closer to one another in the periods of cluster.

Lower incidence of cancer was observed in the women for the period 2001-2003 in the smoothed maps [Figure 5]. The spatial dependency of cancer in women was clustered in 2004, 2005, and 2006 at the significance level of 0.05, so that most of the density was located in Shiraz, Larestan, and their neighboring areas. Similar distribution patterns were observed between counties in the later years.

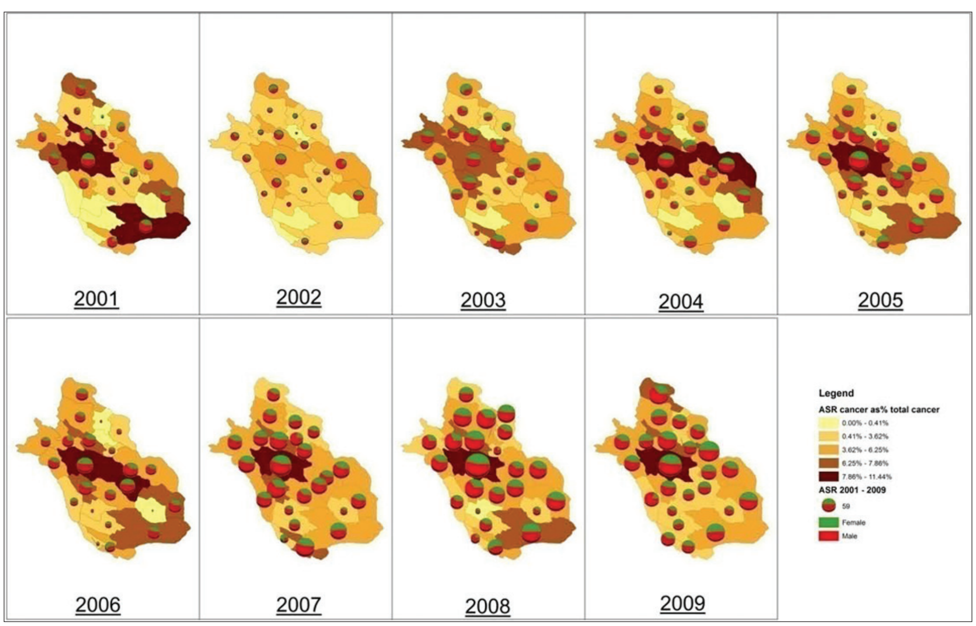

Figure 3: Spatial distribution of cancer in the counties of Fars, during 2001-2009

Table 1: Age-standardized rate in counties of Fars province, Iran, during 2001-2009

County	Mean of population (2001-2009)	Total age-standardized incidence rates								
		2001	2002	2003	2004	2005	2006	2007	2008	2009
Abadeh	92,210	36.75	31.2	37.24	24.48	29.93	72.06	59.77	62.31	124.11
Arsanjan	41,875	9.2	25.9	53.09	53.12	64.72	23.35	88.3	15.56	140.07
Bavanat	46,262	21.11	13.7	19.82	46.38	31.45	15.42	52.71	63.25	71.21
Darab	174,971	36.79	39.09	38.93	67.4	73.46	85.87	82.83	104.4	111.33
Eqlid	103,965	12.17	11.51	27.6	40.22	47.3	54.94	74.02	98.92	85.38
Estahban	67,206	17.2	17.69	28.96	42.54	77.01	99.67	77.48	71.05	72.5
Farashband	44,582	0	13.97	32.73	23.15	24.7	33.42	90.64	48.29	67.18
Fasa	191,550	13.02	10.97	22.65	37.61	83.18	100.3	96.9	84.43	54.69
Firuzabad	114,841	28.24	34.21	55.54	45.54	83.55	91.45	137.26	99.26	78.39
Jahrom	201,115	15.98	13.87	14.77	24.72	37.79	59.69	79.75	75.15	42.33
Kazerun	265,649	37.38	26.25	42.39	52.4	62.04	67.79	106.03	80.73	83.33
Khonj	39,416	0	0	0	0	0	21.57	45.94	45.75	37.76
Khorrambid	44,632	1.96	10.96	19.41	16.82	8.32	3.27	69.79	108.4	68.3
Lamerd	77,210	29.74	19.01	58.34	52.53	58.14	51.46	132.42	64.91	54
Larestan	226,197	45.7	26.76	46.35	47.12	88.76	79.67	99.88	113.9	107.51
Mamasani	165,254	21.58	27.15	50.15	50.42	69.67	47.55	77.95	60.3	77.66
Marvdasht	293,994	45.2	34.69	59.29	63.1	92.89	87.49	124.14	117.5	120.42
Mohr	53,488	0	0	6.2	5.56	8.78	6.94	23.72	21.85	61.44
Nayriz	106,335	26.02	40.8	43.38	76.4	71.5	56.86	104.28	87.98	90.34
Pasargad	30,304	12.25	2.64	0	0	5.07	0	63.27	88.72	58.13
Qir and Karzin	63,969	0	8.89	24.66	20.39	29.64	5.31	28.07	6.34	28.3
Sepidan	89,510	10.87	13.14	35.66	56.38	54.08	62.42	84.3	88.74	70.48
Shiraz	1,679,605	54.42	43.25	60.05	76.71	127.21	117.66	165.98	167.14	162.58
ZarrinDasht	62,351	0	0	4.41	0	12.26	1.41	17.63	16.46	28.04

Table 2: Moran's index of ASR, 2001-2009 (P=0.05)

Year	Moran's index	Z-score	P value	Type of spatial pattern
2001	–0.002	0.355	0.723	Random
2002	0.168	1.114	0.076	Random
2003	0.089	1.115	0.265	Random
2004	0.277	2.703	0.007	Clustered
2005	0.306	2.968	0.003	Clustered
2006	0.268	2.605	0.009	Clustered
2007	0.099	1.236	0.217	Random
2008	0.013	0.489	0.625	Random
2009	0.129	1.488	0.137	Random

ASR=Age-standardized rate

DISCUSSION

The overall global burden of cancer is increasing, so that cancer incidence, diagnostic and treatment facilities, and cancer control programs exist differently in various geographic boundaries of the world. Differences in cancer incidence rate were shown in the Iranian population in the recent years.[6] Our study estimated average ASR of 102.17 and 82.17 per 100,000 persons in men and women, respectively, while in comparison with the findings of Masoompour *et al.*, and Mehrabani *et al.*, have increased incidence and age of illness onset.[11,12] Also, the finding is comparable with studies performed in Semnan and Kerman Provinces.[9,19] Sadjadi *et al.*, showed that in Kerman Province, (neighboring Fars Province) ASR was 76 and 68 in men and women, respectively, while our findings showed higher rates.

In 2002 and also some of counties in other times, the obtained low cancer incidence rate was probably due to incomplete registered data (incomplete forms for residence cities of patients). Overall, cancer increase trend in the present study, maybe related to aging of the population. One of the most important contributing factors to increasing cancer occurrence in the world is due to increased life expectancy and aging of the population.[32] Cancer incidence was higher in the men than women, perhaps due to increase the specific cancers in

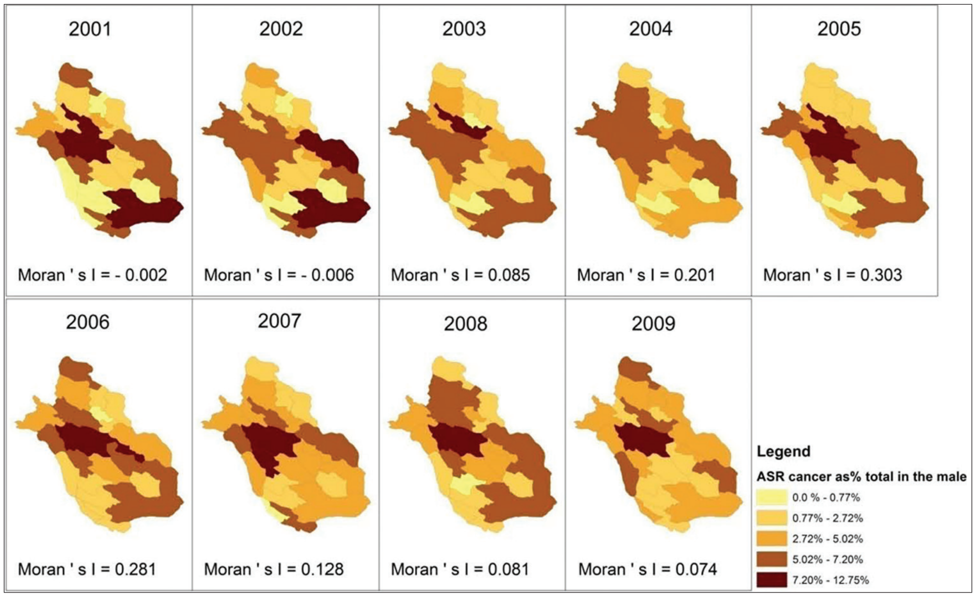

Figure 4: Spatial distribution of cancer in the male, during 2001-2009

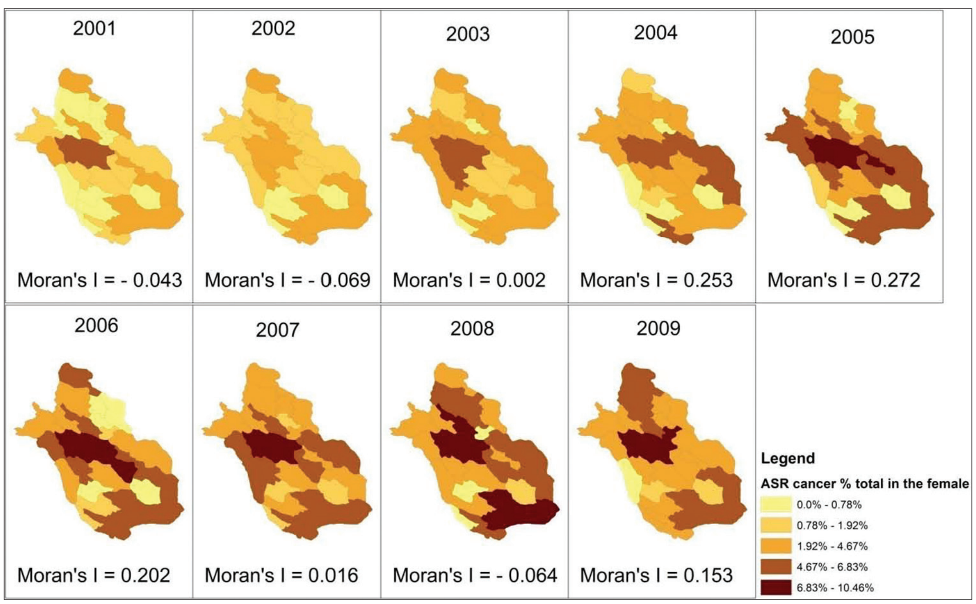

Figure 5: Spatial distribution of cancer in the female, during 2001-2009

men, or being exposed to identified risk factors such as smoking, using alcohol, occupational carcinogens and other agents.[4,33] The mean age of women who developed cancer was lower compared to men, which can be explained by increasing detection with screening tests (pap smear and breast examination), performed in the health care centers. However, women are more concerned about their health, and as a result they visit physicians relatively more, this might result in an earlier detection of cancer.[34]

ASR of Shiraz and Larestan were higher than neighboring cities during years, that maybe due to lifestyle, exposure to industrial pollution, migration of various races and people and influence of genetic and life traditions. Moreover, some patients may move to large cities in order to have better access to more equipped facilities for diagnostic and treatment measures, which can be considered a confounding agent. Also, lack of proper surveillance systems in some health care centers in the underprivileged and small cities can affect our findings. The level of knowledge and attitude of people about health promotion and preventive activities of chronic diseases like cancer may affect distribution of cancer.

In most of southern regions of Fars with low population density, cancer incidence trend was increasing, and it is expected that, ASR will rise even more in future. Therefore it should be a priority for health policy makers for development and implementation of comprehensive cancer control programs. Epidemiological studies should be considered for determining important roles of climate and geographical condition in cancer incidence. The study was conducted in Trabzon, Turkey (Yomralioglu *et al.*) showing that incidence of some cancers have been different in various geographical locations.[1]

While epidemiology of cancer incidence using GIS has been well studied in developed countries, it has not received adequate attention in developing countries.

A review of published studies, we did not find cancer study using GIS in Fars Province. The study was conducted to determine clustering of childhood cancer in Tehran, another was to assess pattern of spread of gastrointestinal cancer in the Caspian sea region. These were not comparable with our study.[8,20] The obtained Moran's I in 2004, 2005 and 2006 show that the distribution of cancer was more regular than other years and spatial clusters were found in Shiraz, Sepidan, Mamasani, Nayriz, Arsanjan, Khorrambid, Bavanat and ZarrinDasht. The clustered patterns suggest that contributing factors may be similar in the mentioned counties, which can be surveyed in future epidemiological studies.

GIS can be used effectively for assessment of cancer incidence, in the geographical location and to provide insights for placing control measures. Of course, researchers should consider although maps help to visually evaluate spatial pattern, they have limitations. Wainwright *et al.*, collected cancer data in Maryland, USA, and analyzed effects of different variables such as population, income, unemployment indicator, and urban and rural areas.[35] This is not possible in our study due to lack of access to accurate information such as socioeconomic conditions. This again signifies the need for a better data collection system in developing countries.

CONCLUSIONS

The spatial analysis by GIS is a method that is feasible and helpful in generating hypothesis and identifying areas for intervention. It could be necessary and important for public health policymakers to promote strategies for cancer control and management for infrastructure. Therefore, knowledge of spatial distribution of cancer is expected to provide accurate and easily accessible information for implementation of preventive activities in community health.

Our study showed spatial analysis of cancer incidence and clustered pattern in the Fars province over a period of time. Further studies are needed on the efficiency of GIS, not only to determine etiological agents of cancer but also to help policy makers in management of health promotion.

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