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ORIGINAL RESEARCH

A Comparative Study of Spatial Distribution of Gastrointestinal Cancers in Poverty and Affluent Strata (Kermanshah Metropolis, Iran)

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Abstract

Introduction The trend of cancers has witnessed a twofold rise in the last three decades, which is expected to be fivefold by 2030. On the other hand, gastrointestinal cancers have turned into one of the health issues in many societies. Given the presence of gastrointestinal cancer hot spots and evidence of health inequalities across Kermanshah Metropolis and the results of studies signaling the association between gastrointestinal cancers and socioeconomic status of individuals as well as evidence of unequal socioeconomic opportunities in this metropolis, the present study aimed to investigate the spatial distribution of gastrointestinal cancers in the poverty and affluent strata of Kermanshah Metropolis, Iran.

Materials and Methods In this descriptive-analytical study, the recorded data of patients, suffering from gastrointestinal cancers, in Kermanshah-based Pathology Centers and Vice Chancellery of Kermanshah University of Medical Sciences (2007–2012) were used. Moreover, to examine the status of gastrointestinal cancers in socioeconomic classes based on the census data collected during 2007–2012, 33 social, cultural, and structural indexes were extracted from the statistical blocks. Additionally, for data analysis and factor analysis, Kruskal–Wallis Test in the environment of SPSS and kernel density estimation (KDE) and Moran's I tests in the GIS environment were employed.

Findings The results of the present study revealed that the distribution of poverty (Z score = 48.916518, p value = 0.000000) and affluent strata (Z score = 14.345028, p value = 0.000000) followed clustered patterns ($p < 0.01$). Additionally, the results indicated that the spatial distribution pattern of the upper gastrointestinal cancer was clustered (Z score = 1.896996, p value = 0.007828), whereas the spatial distribution pattern of the lower gastrointestinal cancer was inclined to a randomized clustered pattern (Z score = 1.338121, p value = 0.000857) ($p < 0.01$). Finally, seven main hot spots were identified from the poverty stratum in Kermanshah, which perfectly overlapped the hot spots of upper gastrointestinal cancer. Similarly, four main hot spots were identified from the affluent stratum in Kermanshah, which overlapped the hot spots of lower gastrointestinal cancer. The results of the Kruskal–Wallis Test demonstrated that the poverty and affluent strata were significantly different from each other in terms of gastrointestinal cancer: upper gastrointestinal cancer ($p < 0.05$ and X^2=10.064) and lower gastrointestinal cancer ($p < 0.05$ and X^2=10.253).

Conclusion The results of the present study showed that the ratio of patients with lower gastrointestinal cancers was higher than the incidence of upper gastrointestinal cancers over the 5-year period under study. Moreover, in Kermanshah Metropolis, there was a significant difference between the upper gastrointestinal cancer in the poverty stratum and the lower gastrointestinal cancer

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in the affluent stratum. Hence, it is suggested that GIS be applied as a tool for identifying the patterns of effective factors of this type of cancer in each social class, and it is recommended that some effective policies be presented and adopted by health managers according to the role and importance of socioeconomic, environmental, and nutritional factors in the poverty and affluent strata of society, and people at risk be equipped with preventive training programs in this respect.

Keywords Gastrointestinal Cancer · Poverty and affluent strata · Kermanshah · GIS

Introduction

In 1970, 85% of the reported cancers occurred in developed countries, and only 15% were in developing countries [1]. But now, about 70% of the cases of cancers are in developing countries [2]. Over the past three decades, the incidence of chronic diseases has doubled, and it is anticipated that this trend will be fivefold by 2030 [3]. Cancer is the second leading cause of death among chronic illnesses and is expected to be the leading cause of mortality even ahead of cardiovascular diseases over the next few years [4]. Moreover, gastrointestinal cancers are known as the most common cancers in various societies, with an estimated 26.1 cases per 100,000 Iranian population [5]. Not to mention, the rates of incidence of esophagus, stomach, and colorectal cancers are 3, 12, and 1.5 cases per 100,000 population [6]. In addition, among the central and southwestern Asian countries, Iran has the highest mortality rate due to gastrointestinal cancers (19.9 per 100,000 population) [5].

Some of the reasons for the rise in this disease are the relative control of contagious diseases [7], increased life expectancy, lifestyle changes, increased environmental risk factors, genetic predisposition, and aging population [8]. The socioeconomic and geographic conditions of citizens also affect the health of communities [9]. Accordingly, diseases follow a specific pattern among social classes. In this regard, research has it that there is a relationship between colon cancer and people with high socioeconomic status [10–12], and the results are indicative of the association between poverty and stomach cancer [13, 14]. In other words, living in poverty areas has affected the level of getting cancers [13]. The reason why this is important is that patients with inappropriate socioeconomic conditions who are suffering from cancers are more damaged by the consequences of illnesses [15]. In recent years, there has been evidence that health inequalities have increased between the poverty and other urban residents [16], which is generally attributed to environmental conditions and the lack of adequate sanitation in slum areas where mainly poverty residents live. The inability of growing communities to eliminate poverty is one of the most obvious examples of failure in cancer prevention because in the process of developing a cancer, the risk of poverty people's exposure to death is greater than that of the rich. Hence, it seems that overcoming the problem of poverty and cancer is a special and very challenging issue [14, 17].

Despite the high mortality rates of cancers, it is estimated that more than one third of the cases can be prevented and one third is potentially curable subject to early diagnosis [6]. Due to these reasons, as well as the fact that cancers are one of the major noncontagious diseases and their sky-high costs of diagnosis and treatment and their specific nature, cancers are of particular importance in health system programs and are one of the research priorities worldwide. In this regard, adopting epidemiological approaches and awareness of the geographical distribution of the incidence of cancers can be one of the first steps towards relevant planning, thereby playing fundamental and successful roles in combating cancers [3, 18]. The realization of this goal depends on access to adequate and accurate information on the rate and manner of the occurrence of this disease in social groups and different age ranges, as well as the sexual, geographical, and ethnic conditions of the region [6, 19].

Geographic methods, ranging from local to global scales, are needed for analyzing health data, so that the relationship between diseases and economic and social conditions can be discovered through disease patterns in geographic spaces [20]. Nowadays, the application of geographic information systems (GIS) has made it possible for authorities to provide significant assistance to public health through correct planning [21–32]. One of the major capabilities of this software is the spatial clustering techniques whereby disease clusters are explained, the incidence and prevalence of diseases are identified in different geographical environments, and the socioeconomic conditions of citizens are supported [33].

The results of reviewing literature suggest that numerous studies have been conducted to investigate the geographical variation of gastrointestinal cancers using GIS across various nations [34, 35]. Similar studies have been performed in Iran [36, 37]. Moreover, valuable studies have been done on the relationship between gastrointestinal cancers and the socioeconomic status of individuals [38–40]. However, no previous studies have been undertaken about the association between the different kinds of gastrointestinal cancers and their distribution in the poverty and affluent strata using GIS, and the present study is the first work in this respect.

Given that gastrointestinal cancers are one of the important health problems of societies, including Iran, and considering the existence of unequal socioeconomic opportunities in Kermanshah [25, 41, 42], as well as the formation of geographical hot spots associated with gastrointestinal cancer

throughout the city [43] and the existence of evidence related to the relationship between socioeconomic status and gastrointestinal cancers, the present study aimed to investigate the spatial distribution of gastrointestinal cancers in the poverty and affluent strata of Kermanshah Metropolis, Iran.

Materials and Methods

In this descriptive-analytical study, the recorded data of patients, suffering from gastrointestinal cancers, in Kermanshah-based Pathology Centers and Vice Chancellery of Kermanshah University of Medical Sciences (2007–2012) were used. In the next step, all data and information of these patients were entered into the ArcGIS Software environment and were encoded in two groups: esophageal and stomach cancers fell into the upper gastrointestinal cancers, whereas cancers relating to small and large intestines, the area between the large intestine and end of the colon, rectum, and other digestive tract areas fitted into the lower gastrointestinal cancers [44, 45].

To examine social classes (poverty and affluent) across Kermanshah Metropolis, the information from the census conducted inside Iran in 2012 as well as the 33 social, cultural, and structural indexes extracted in the environment of ArcGIS were used (see Table 1) [41]. In this regard, the statistical blocks of Kermanshah in the environment of ArcGIS were used to obtain the demographic information. A statistical block refers to a set of interconnected structures (or interconnected buildings and terrains) surrounded by roads (streets, squares, streets, etc.) or natural features (rivers, mountains, trenches, etc.). This feature is the most important one in urban statistical maps.

Then, 33 indexes were transferred to the SPSS software, and eigenvalues, percentage of variance, cumulative variance, and difference coefficient (the gap between blocks) were determined for each of the factors using the capabilities of the factor analysis model in four indexes (social, economic, cultural, and physical). In other words, having considered the values of the factors (eigenvalues, percentage of variance, etc.), some combinations of variables whose correlations showed the highest observed variances were first selected, and the social index was obtained. Then, based on variables with the highest share in explaining the remaining variance, the economic, cultural, and physical indexes were extracted. Finally, four indexes were combined and the city blocks were extracted under two poverty and affluent groups.

To examine the spatial pattern of gastrointestinal cancers in poverty and affluent social classes, Moran's I test in the GIS environment was used, which is calculated as follows (see Eq. 1) [46]:

$$I = \frac{n}{s_o} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} wij\left(Xi-\overline{X}\right)\left(Xj-\overline{X}\right)}{\sum_{i=1}^{n}\left(Xi\%-\overline{X}\right)^2} \quad (1)$$

Where,

N	Number of items
Xi	Value of the variable in a specific location
Xj	Value of the variable in another location
X	Mean of the variable
Wij	Weight applied for comparison between the locations I and j
Wij	A weighted matrix based on the distance and it is the inverse distance between locations i and j

To examine the relationship between the poverty and affluent citizens and the upper and lower gastrointestinal cancers, the Kruskal–Wallis test in the environment of SPSS and kernel density estimation (KDE) in the GIS environment were employed.

Table 1 Indexes used to measure social classes in both poverty and affluent groups

Row	Indexes used to measure social classes	
1	Social indexes	Young population, aging, average household size
2	Economic indexes	Dependency burden, unemployment rate, male unemployment, general activity, employment coefficient, gross dependency burden, dependency coefficient, rate of employment, net dependency burden, unemployment, economic participation, women's participation in economic activities, overhead, livelihood, population burden (economic burden)
3	Cultural indexes	Literacy ratio, illiteracy rate, employment rate, illiteracy rate in the population in need of education, literacy rate of adults
4	Structural indexes	Population density, building density, population density in buildings, gross residential density, net residential density, household density in buildings, individual density in buildings, residential density of population, net residential per capita, gross residential per capita

Findings

According to the findings, during the 5-year period, about 283 cases of gastrointestinal cancer have been reported, of which about 126 and 157 cases have been related to upper and lower gastrointestinal cancers, respectively (see Table 2).

In Fig. 1a, the distribution of upper and lower gastrointestinal cancers across Kermanshah Metropolis is shown. As can be seen, most of the upper gastrointestinal cancer is concentrated in the eastern and central regions of the region, while the hot spot of the lower gastrointestinal cancer is more located in the southern, central, and western parts of Kermanshah. It is noteworthy that both types of cancer are prevalent in northern parts of the city. As shown in Fig. 1b, the majority of the poverty population is located in the eastern and central parts of the city, whereas the majority of the wealthy stratum is in western and southern parts of Kermanshah.

To study the spatial patterns of social classes and gastrointestinal cancer, Moran's I Index was used (see Table 3). According to the results, the distribution of poverty (Z score = 48.916518, p value = 0.000000) and affluent strata (Z score = 14.345028, p value = 0.000000) followed clustered patterns. Additionally, the results indicated that the spatial distribution pattern of the upper gastrointestinal cancer was clustered (Z score = 1.896996, p value = 0.007828), whereas the spatial distribution pattern of the lower gastrointestinal cancer was inclined to a randomized clustered pattern (Z score = 1.338121, p value = 0.000857).

The Kruskal–Wallis test was used to examine the significance of the difference between the poverty and affluent strata in terms of gastrointestinal cancer. The results of this test demonstrated that the upper ($p < 0.05$ and X^2=10.064) and lower ($p < 0.05$ and X^2=10.253) gastrointestinal cancers significantly differed. Using the KDE test in the GIS environment, the hot spots of the upper and lower gastrointestinal cancers are precisely shown in the poverty and affluent populations of Kermanshah (see Fig. 1). Based on the findings, the hot spots of poverty populations in Kermanshah are closely overlapping with the upper gastrointestinal cancers (see Fig. 2a, b), while the hot spots of affluent populations in Kermanshah are closely overlapping with the lower gastrointestinal cancers (see Fig. 2c, d). Finally, seven main hot spots were identified from the poverty stratum in Kermanshah, which perfectly overlapped the hot spots of upper gastrointestinal cancer. Similarly, four main hot spots were identified from the affluent stratum in Kermanshah, which overlapped the hot spots of lower gastrointestinal cancer.

Discussion

The present study aimed to analyze the spatial association of gastrointestinal cancer in the poverty and affluent classes in Kermanshah Metropolis, west of Iran. Having focused on spatial distribution and application of GIS in Kermanshah Metropolis, the present work was the first attempt to compare the gastrointestinal cancer and socioeconomic status of people in Iran.

The results of the present study indicated that over 2012–2007, out of a total of 283 patients suffering from gastrointestinal cancer, 126 and 157 cases had upper and lower gastrointestinal cancers, respectively. The larger proportion of lower gastrointestinal cancer in the present study was concurrent with the results of studies performed by Rohani Rasaf et al. [47] and Greenlee and Howe [9], while inconsistent with the results of studies done by Zahedi et al. [48] and Gelband et al. [49]. Among the upper gastrointestinal cancers, stomach cancer has the highest incidence (78%), as opposed to colon cancer among the lower gastrointestinal cancers (63%). The high incidence of stomach and colon cancers is consistent with the results of studies conducted by Almasi et al. [18] in Markazi Province, Babaie et al. [50] in Semnan Province, Sajadi et al. [51] in Ardabil Province, Norouzinejad et al. [52] in Mazandaran Province, Bagheri Lankarani et al. [53] in Fars Province, Yazdanbod et al. [54] in Ardabil Province, and Vakili et al. [55] in Yazd Province. The results of the present study were slightly different from those of Borji et al. [6] in Neishabour County in which esophageal cancer had the

Table 2 Gastrointestinal cancer statistics for the period 2007–2012

Gastrointestinal cancer	Upper gastrointestinal cancer	Cancer type	Frequency	Percentage
		Esophagus	28	22.23
		Stomach	98	77.77
		Total	126	100
	Lower gastrointestinal cancer	Small Intestine	3	1.92
		Colon	98	62.82
		Rectosigmoid	13	8.33
		Rectum	37	23.72
		Anus	3	1.92
		Others	3	1.92
		Total	157	100

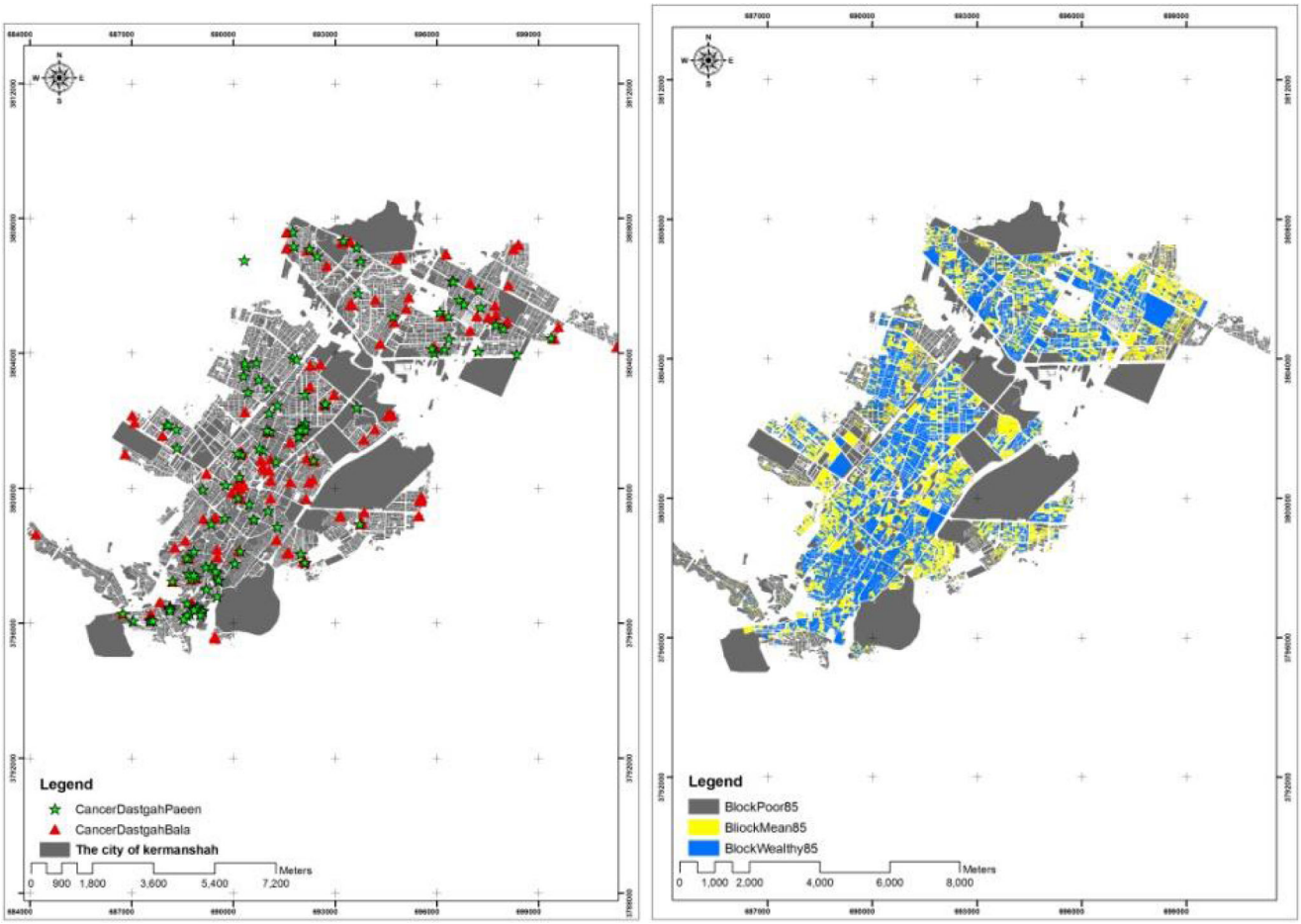


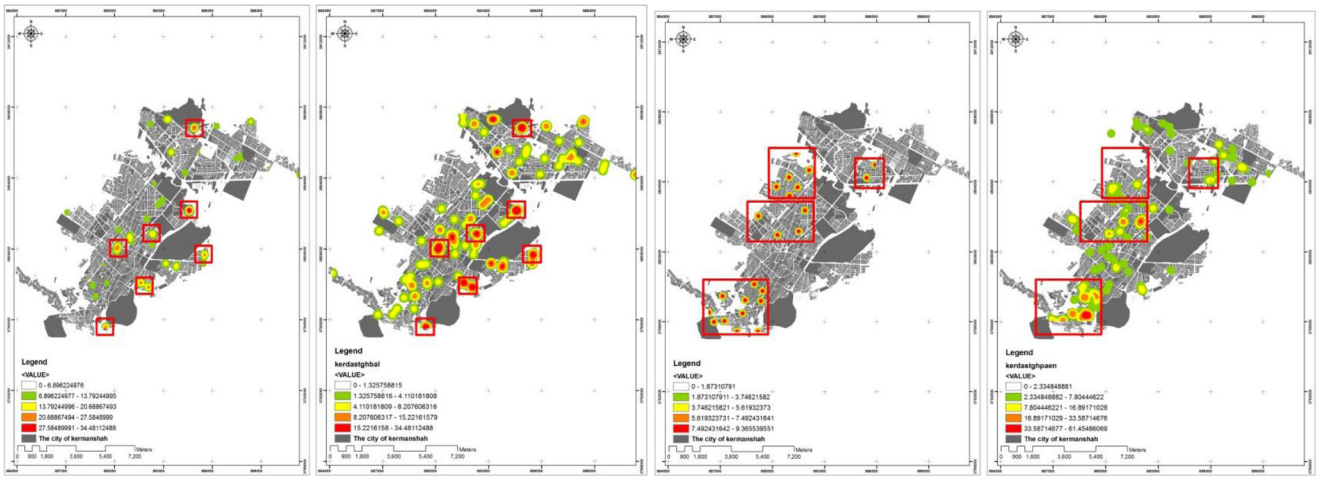
Fig. 1 **a** The distribution of upper and lower gastrointestinal cancers. **b** The distribution of poverty and affluent blocks in Kermanshah Metropolis

highest percentage, as opposed to stomach and colon cancers in the present study. The high prevalence of stomach and colon cancers in comparison with other gastrointestinal cancers in Kermanshah Metropolis is consistent with the results of other studies conducted worldwide [4, 56, 57], which requires more extensive studies on their prevalence and root causes.

The results of Moran's I Index were indicative of the fact that the poverty and affluent citizens were clustered in Kermanshah Metropolis. In other words, there is social separation between poverty and affluent neighborhoods in Kermanshah. This finding was consistent with the results of studies conducted by Rostaie et al. (2012) and Hataminejad et al. (2008) [41, 58]. The importance of this issue is because of the effects of socioeconomic structures on changes in mortality from gastrointestinal cancers, which has been stressed in a study performed by Mohammadpour Tahamtan et al. (2013) in both Mazandaran and Golestan Provinces, Iran [36] [25].

Table 3 Predictive values, variance, and *Z* score based on the variables of cancer and poverty and affluent strata

	Poverty	Affluent	Upper gastrointestinal cancers	Lower gastrointestinal cancers
Moran's I Index	0.325706	0.073416	0.267267	0.117009
Expected	− 0.000451	− 0.000356	− 0.007519	− 0.007813
Variance	0.000044	0.000026	0.020982	0.008701
Z score	48.916518	14.345028	1.896996	1.338121
p value	0.000000	0.000000	0.007828	0.000857



a Hot spots of Poverty populations

b Hot spots of the upper gastrointestinal cancers

c Hot spots of affluent populations

d Hot spots of the lower gastrointestinal cancers

Fig. 2 **a** The hot spots of poverty populations. **b** The hot spots of the upper gastrointestinal cancers. **c** The hot spots of affluent populations. **d** The hot spots of the lower gastrointestinal cancers

This is vital for planning health interventions in poverty and affluent neighborhoods. The results indicated that the spatial distribution pattern of the upper gastrointestinal cancer was clustered, whereas the spatial distribution pattern of the lower gastrointestinal cancer was inclined to a randomized clustered pattern. This finding was consistent with the results of studies conducted by Goovaerts and Jacquez (2005) [46], Colonna and Sauleau (2013) [59], Lemke et al. (2013) [60], Ahmadi and Zahrani (2013) [61], and Mohebi et al. (2011) [62]. In the study done by Mohebi et al. (2011), the SAS (Statistical Analyzing System) Software was used, but the GIS Software was employed in the present study. The superiority of GIS software over SAS software is due to using location as one of the variables. Hence, in addition to the descriptive data, spatial data was used simultaneously.

In the present study, data were analyzed and cancer hot spots were identified using the GIS software and Moran's I Index, which was similar to a study conducted by Askarian et al. (2014) [37]. However, the present study was different from the said study in terms of the scope under study. In other words, Askarian et al. (2014) studied each county as the units of analysis, but the statistical blocks of Kermanshah were considered the units of analysis in the present study. To put it simply, the cancer hot spots were identified at the level of urban blocks, which are considered to be the most important elements in urban statistical maps.

As mentioned in "Introduction," cancerous diseases are multifactorial diseases that can be attributed to several etiologic factors associated with the incidence of gastrointestinal cancers, including (1) social and environmental determinants such as social class and ethnicity [63, 64], occupational hazards [65], location, and place of residence [48]; (2) physiological factors such as obesity [66]; and (3) lifestyle factors such as smoking and nutrition status [67, 68].

Given the nutritional differences in various societies [69, 70], it is expected that different groups in society have specific patterns in a variety of cancers. As the pattern of food intake varies between the poverty and rich [71], and the prevalence of food insecurity is higher in households with low economic status [72], the nutritional behaviors associated with stomach cancer may also be mentioned [73]. Accordingly, it is likely that the difference in the nutritional status of individuals accounts for the distribution of upper and lower gastrointestinal cancers in the poverty and affluent classes of Kermanshah. Similarly, Pasdar et al. (2014) pointed to the nutritional differences in children living in Kermanshah [74]. In this regard, adopting diets [75] will be particularly effective, especially in gastrointestinal patients [76]. Moreover, obesity and overweight are two other factors that affect gastrointestinal cancers. Some studies have shown that obesity is more likely to occur in people with lower socioeconomic status [77]. Similarly, the results of a study conducted in Kermanshah have confirmed the presence of obesity in low socioeconomic classes, too [78]. It is likely that obesity in poverty neighborhoods is a factor in the distribution of upper gastrointestinal cancers in the poverty hot spots of Kermanshah. In addition, those with low socioeconomic status in Kermanshah are from different ethnic groups living in poverty neighborhoods because of their familial history. Therefore, it is likely that family history and ethnicity are associated with upper gastrointestinal cancers in this metropolis. As in other studies, it has been shown that esophageal and stomach cancers are associated with first- and second-degree relatives [45, 63, 79]. Finally, seven main hot spots were identified from the poverty stratum in Kermanshah, which perfectly overlapped the hot spots of upper gastrointestinal cancer. Similarly, four main hot spots were identified from the affluent stratum in Kermanshah, which overlapped the hot spots of lower gastrointestinal

cancer. These results are indicative of the association between different groups of society (classes) and gastrointestinal cancers in Kermanshah Metropolis (see Table 1 and Figs. 1 and 2). To put it simply, people with different socioeconomic conditions have different cancer patterns, which is consistent with the results of a study conducted in the USA, in which the type of cancer and the socioeconomic status of people were found to be associated [39]. This finding was also concurrent with the results of a study conducted in the UK, in which it was shown that there was a difference in the incidence of cancers in the north and south of England, which was introduced as a link between deprivation and incidence of cancer [80].

In the present study, the spatial correlation between the upper gastrointestinal cancer and poverty neighborhoods in Kermanshah was positive, indicating that the hot spots of poverty class and upper gastrointestinal cancer were overlapping (Fig. 2a, b). Similarly, the hot spots of affluent class and lower gastrointestinal cancer were overlapping (Fig. 2c, d). Similarly, given these points and the things previously mentioned, location and place of residence are important factors in the distribution of gastrointestinal cancers. For example, in a country like Egypt, this kind of cancer has a very low incidence, as opposed to a high prevalence in a country like Japan [81].

Another efficacious factor is the late diagnosis of the disease. In this case, the media can play a key role since the media's neglect of cancer can be a major contributor to the low participation of people in screening programs [82]. As in Iran, lack of knowledge in this regard has been associated with lack of announcements by the media [73]. This is important because cancer hot spots have been developed across Kermanshah, but health services have not been distributed equally throughout the region [22, 83].

When the prevalence and spatial distribution of this disease are mapped, significant differences are observed from one point to another, which cannot be explained only by genetic, dietary, and social differences. However, the correlation between diseases and elements can be figured out through drawing the spatial distribution map and frequency of diseases with the help of GIS [21, 84]. One of the strengths of the present research was the application of GIS as a tool for investigating gastrointestinal cancers in the poverty and affluent classes. Another plus was the investigation of the types of gastrointestinal cancers in poverty and affluent classes, which was something new in Iran so far. Based on the results of the present study, the upper and lower gastrointestinal cancers were the most common cancers in the poverty and affluent classes in Kermanshah Metropolis, respectively. Hence, identifying and preventing the effective factors of these two common types of cancer are of prime importance. To this end, some educational programs should be provided to people at risk to prevent this cancer, and some general education should be supplied through separate and systematic planning by health managers about the roles and importance of environmental and nutritional factors in the poverty and affluent classes. It is also necessary to carry out in-depth and accurate studies of the factors affecting the bipolarization of the gastrointestinal cancer in poverty and affluent communities in Kermanshah. Additionally, the application of GIS, as an applied tool for cancer-related health considerations, should be considered by organizations.

Conclusion

The results of the present study revealed that the ratio of patients with lower gastrointestinal cancers was higher than the incidence of upper gastrointestinal cancers over the 5-year period under study. Among the upper gastrointestinal cancers, stomach cancer has the highest incidence, as opposed to colon cancer among the lower gastrointestinal cancers. As for studying the spatial pattern of social strata, the clustering feature of poverty and affluent citizens was confirmed. In other words, there is social separation between the poverty and affluent neighborhoods in Kermanshah. Additionally, the results indicated that the spatial distribution pattern of the upper gastrointestinal cancer was clustered, whereas the spatial distribution pattern of the lower gastrointestinal cancer was inclined to a randomized clustered pattern. Finally, seven main hot spots were identified from the poverty stratum in Kermanshah, which perfectly overlapped the hot spots of upper gastrointestinal cancer. Similarly, four main hot spots were identified from the affluent stratum in Kermanshah, which overlapped the hot spots of lower gastrointestinal cancer. The results demonstrated that there was a significant difference between the upper gastrointestinal cancer in poverty stratum and lower gastrointestinal cancer in affluent stratum.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

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