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Spatial patterns analysis and hotspots of HIV over 20 years using geographic information system. A case study of Kermanshah, West Iran

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Abstract

Introduction: Nowadays, human immunodeficiency virus (HIV) has turned into a major health predicament worldwide, varying from country to country, and geographic studies performed in Iran on HIV are limited. So, the present study aimed to use spatial patterns analysis and analyze hotspots of HIV over the period 1994-2013.

Material and methods: The research method was descriptive, analytic, and cross-sectional. Additionally, the recorded data on HIV-stricken patients based in the Kermanshah County over 1994-2013 were used, and the spatial trends of HIV were analyzed by Arc/geographic information system (GIS).

Results: Nearly 3318 inhabitants based in Kermanshah were proven to be infected with HIV over 20 years, of whom 92% were male and 8% were female. Moreover, intravenous drug users had the highest percentage of being infected with HIV (85%). Studying the spatial trends of HIV demonstrated that the majority of infected people were based in Kermanshah County (88%).

Conclusions: During the past 20 years, the number of HIV-stricken women has had an upward trend, and the possibility of being infected through intravenous drug injection and sexual intercourse was reported the same in 2013. HIV prevalence increased in Kermanshah Province and three hotspots were identified there. Managers can use the results of the present study when planning for health-related practices such as those related to HIV.

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Key words: HIV, Iran, GIS, Kermanshah, spatial patterns.

Introduction

Human immunodeficiency virus (HIV) is an epidemic disease causing serious challenges worldwide, threatening the general welfare of humans in a way that has turned into one of the major public health problems in the world [1, 2]. Due to the rapid transmission of epidemic diseases and the resulting potential effects on societies, the early detection of such epidemics is the top priority of public health. The world statistics published in 2014 showed that there were 34 million people infected with HIV worldwide, of whom 4.8 million people were based in Asia [3], and according to the statistics provided by the Ministry of Health of Iran, more than 27 thousand HIV-stricken patients were identified by 2014, of whom 89.3% were male and 10.7% were female [4].

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The number of new cases of the disease is still growing, varying from one country/region to another [5]. The spatial analysis of contagious diseases, as one of the effective etiological methods, is given utmost importance and priority, together with growing evidence indicating that the dynamic spatial data are key elements in monitoring and predicting the spread of contagious diseases [6-8]. Despite the significant geographic variations in HIV, the analysis of the spatial distribution of this disease has been paid less attention [2, 9]. However, like other contagious diseases, understanding the spatial variations in the prevalence of HIV and its stimulants in socio-spatial contexts causes the preventive interventions to be carried out with more appropriate planning [10-12], and to this end, the geographic analytic technique of the geographic information system (GIS) is a powerful tool [10, 13, 14] whose main feature is the possibility of understanding geographic patterns in space and time [15]. GIS is a powerful source for the health of communities, with capabilities like the integration of data from different sources towards generating new information and intrinsic visualization applications, which can leave lasting effects on the lives of people through creative problem-solving [10, 12].

Many studies have been carried out worldwide on the epidemiology and spread of HIV using GIS [2, 10, 12-14, 16-20]. But given the importance of geography in health, unfortunately, the number of geographically explicit studies on HIV is still so limited that, according to investigations so far, only one case study has been performed on the spatial distribution of HIV in Iran [21]. The present work is among the first studies done in this regard in Iran, and given that there are significant weaknesses in the implementation of the existing policies, the performance of organizations and the design of new policies against HIV [22], it seems that some basic steps can be taken towards HIV prevention and the principles and requirements of decision-making, planning and the required actions by all agencies, particularly the health care system and all engaged sectors, can be better formulated through the agency of sufficient knowledge and understanding of the epidemiological status and spatial trends of HIV throughout Iran. Furthermore, the results of the present study can provide useful insights into better understanding of the dynamics of HIV in Iran and other countries, especially the developing ones, and help the knowledge about this disease be globally deepened. Therefore, considering the above-mentioned material and the lack of accurate and scientific data related to patients suffering from HIV in Iran (Kermanshah Province), the present work was intended to provide the Iranian health managers and policymakers with some scientific insights through analyzing the spatial trends of HIV over 20 years.

Material and methods

The research method used in the present study was descriptive, analytic and cross-sectional, and the statistical population consisted of all patients diagnosed with HIV in Kermanshah Province. Furthermore, the data on the HIV-stricken patients were collected from the files recorded in the Vice Chancellery of Kermanshah University of Medical Sciences, Department of Contagious Diseases. Moreover, the resulting demographic and background information included gender, education, probable routes of transmission of the disease, patients' survival status and leading causes of death. To obtain the descriptive statistics, graphical models and spatial trends of the disease, the GIS Software was used. First, all patients' data were collected from their recorded files in the Department of Contagious Diseases of Kermanshah University of Medical Sciences, then the collected data were changed into a database (GEO database) in the environment of Arc/GIS 10.2.2 Software, and each case of the disease was entered as a point on the map of Kermanshah according to the patients' addresses. To identify the spatial patterns of HIV in Kermanshah Province, the graphic-based statistical models were used in the environment of GIS. The tests used in GIS included mean center, standard distance, and Moran index (equations 1, 2, and 3):

Equation 1:
$$X = \sum_{i=1}^{N} \frac{Xi}{N} \quad Y = \sum_{i=1}^{N} \frac{Yi}{N}$$

Equation 2:
$$SD = \sqrt{\sum {Di^2}/{N}}$$

Equation 3:
$$I = \frac{n}{s_0} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} wij(X_i - X)(X_j - X)}{\sum_{i=1}^{n} (X_i - X)^2}$$

Results

Nearly 3318 inhabitants based in Kermanshah were reported to be infected with HIV during 1994-2013, of whom 92% were male and 8% were female. Moreover, intravenous drug users had the highest percentage of being stricken with HIV (85%), which was 13% in the case of being stricken through sexual intercourse. Of all 3318 infected with HIV, 1127 patients died of HIV (45.94%) and addiction (through overdose) (21.09%) (see Table 1).

Studying the trends of HIV over the period under study in Kermanshah Province showed that the majority of the recorded cases were related to 1997 and 2001-2005 (Figure 1A). However, during the past few years, women showed upward trends (Figure 1B). Furthermore, the number of dead with HIV was more than the living ones over the period 2006-2007, and 2013 (Figure 1C). Also, studying the causes of the infected patients' death demonstrated that the leading cause of their death was HIV per se, and it was only in 1997 that suicide was reported as the most common cause of death (Figure 1D). Intravenous drug injection had the highest degree of transmission compared with other routes. Over the past 20 years, intravenous drug injection and sexual intercourse had downward and upward trends, respectively,

Table 1. Descriptive statistics of patients infected with HIV within the period under study

Factor	Number	Percentage
Gender		
Male	3038	91.56
Female	280	8.44
Total	3318	(100)
Education		
Illiterate	1147	34.6
Elementary school	811	24.4
Junior high school	957	28.8
Senior high school	364	11.0
Higher education	39	1.2
Total	3318	(100)
Probable routes of transmission		
Intravenous drug addiction	2831	85.3
Sexual intercourse	444	13.4
Mother to child	32	1.0
Cutting objects	8	0.2
Blood products	3	0.1
Total	3318	(100)
Patients' survival status		
Alive	2191	66.03
Dead	1127	33.97
Total	3318	(100)
Leading cause of death		
HIV	538	45.94
Addiction (through overdose)	247	21.09
Suicide	52	4.45
Others	334	28.52
Total	1171	(100)

which were reported the same in 2013 (Figure 1E). Comparing the age groups infected with HIV showed that the 35 to 44 age group had the highest percentage over 1995-1997, and the 25 to 34 age group made up the majority infected with HIV over 1998-2013 (Figure 1F).

Studying 14 townships based in Kermanshah Province demonstrated that Kermanshah County had the largest number of HIV-stricken patients (88.5%), and the majority of reports of the disease were within 2001-2007 (see Table 2). Moreover, studying the prevalence of this disease in Kermanshah Province during the first period (1994-2000) indicated the presence of four townships with more than 16 cases of the disease. Furthermore, in the second period (2001-2007), the number of townships increased to seven, and in the third period (2007-2013), this volume increased to 10 townships (Figure 2).

To study the spatial trends of HIV, the mean center and standard deviation oval were used. The standard deviation oval indicated that HIV was dispersed and increased over the period 1994-2013, in a way that the spread of the disease had a west-east direction in the first period (1994-2000). In the second period (2001-2007) the spread of the disease drew northeast-southwest, and in the third period (2007-2013) it progressed in the four directions of North, South, West, and East. It is noteworthy that the mean centers of all three periods were in Kermanshah County (Figure 3A). Furthermore, clustering the townships of Kermanshah Province showed the presence of three hot spots in the vicinity of each other, i.e. Kermanshah, Harsin, and Islam Abad (Figure 3B).

Discussion

The present study aimed to investigate the spatial distribution and trends of HIV in Kermanshah Province over 20 years, i.e., 1994-2013, and it is the first study looking into the spatial distribution of HIV in western Iran with an emphasis on Kermanshah Province. The results demonstrated that about 11% of all HIV-stricken patients in Iran are based in Kermanshah Province, and the distributions of the disease were focused in three townships in the form of clusters.

The results showed that 3318 patients infected with HIV were recorded in Kermanshah Province over 1994-2013, which was about 11% of all HIV-stricken patients in Iran (170 cases per 100,000 people) while 2.5% of the total population of Iran is based in Kermanshah Province. To explain this finding, it can be expressed that one of the aspects of HIV has its roots in unemployment and poverty [23], and this province also has high statistics of unemployment and poverty [24, 25]. Therefore, it is possible that the main reasons for the proliferation of HIV in Kermanshah Province are unemployment and poverty. According to a study performed by Ghanbarnejad *et al*., Kermanshah Province (796 cases) held around nine times more HIV-stricken patients than Hormozgan Province held (88 cases) within 2007-2011. This difference may be due to the miscalculated statistics related to the HIV-stricken patients in Hormozgan Province and the better performance of the monitoring system in Kermanshah Province. However, comparing the statistics related to the HIV-stricken patients in northern Taiwan (1264 cases) [19] with the size of the infected population in Kermanshah (2515) within 1997-2008 demonstrated that Kermanshah held twice as many HIV-stricken patients than northern Taiwan. Therefore, these statistics are of great significance for health managers and policymakers of Kermanshah Province and Iran.

Studying the trend of HIV in Kermanshah Province over 20 years indicated that the majority of cases were registered in 1997. The period 2005-2001 held the second position in this regard (Figure 1A). Also, the trend of HIV in terms of gender over 20 years showed that the male population made up the highest percentage of patients infected with HIV (92%), forming the dominant population in this case. The national statistics also indicate that there are more men (89%) than women in terms of HIV infection [4]. It is noteworthy that

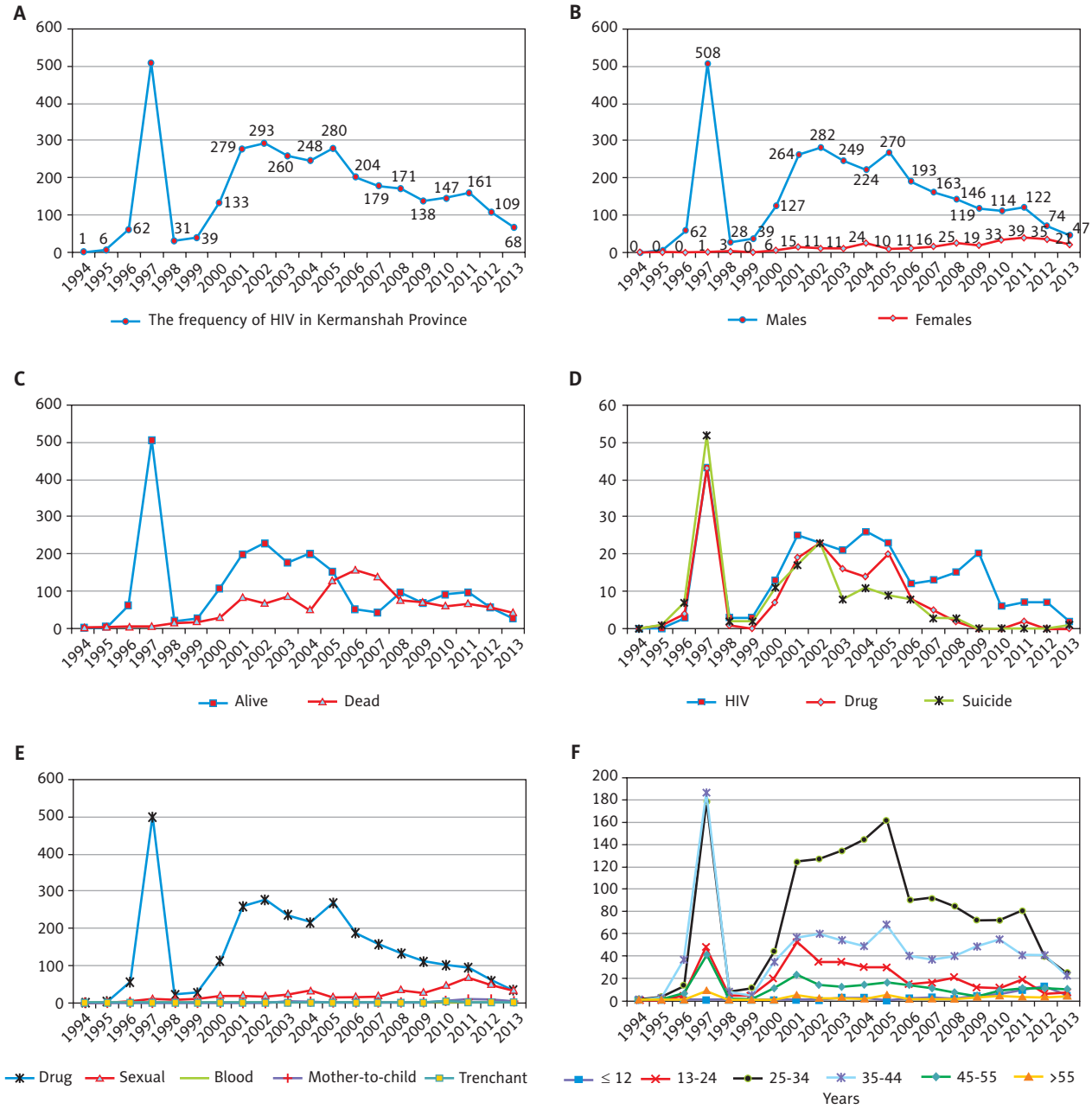

Figure 1. The trend of HIV across Kermanshah Province over 20 years. **A)** The trend of HIV across Kermanshah Province. **B)** The trend of HIV in terms of gender over 20 years. **C)** HIV-stricken patients' status in terms of survival. **D)** The leading cause of the HIV-stricken patients'. **E)** The probable routes of transmission of the disease. **F)** The age brackets infected with HIV

during the period under study, the female population had an upward trend; for example, in 1997, there was only one woman (0.19%) infected with HIV compared with 508 men, whereas in 2013, this proportion changed to 21 (30.88%) women versus 47 men (Figure 1B). Since most Iranian women are young and at childbearing ages [26], they are more susceptible to HIV and the serious consequences of this disease, resulting in irreversible damage to females. By comparison with other countries, for example Kenya, the percentage of women infected with HIV is higher than that of men (55%) [27], which is possibly due to virus transmission routes. In terms of patients' survival, about 34% died, and comparing its 20-year trend showed that the number of patients living with HIV was more than the dead ones over the period under study, except for 2006, 2007 and 2013 (Figure 1C). This situation might have been affected by the use of antiviral drugs during the past few years [28]. Of the 1127 people who died, 45.94% of deaths were because of HIV, 21.09% because of addiction (through overdose) and 4.45% because of suicide. These statistics show that HIV has been the leading cause of mortality of patients.

Table 2. The trend of patients infected with HIV within the period under study

Row	County	HIV cases	Percentage	Population	HIV rate per 100 000 population	HIV cases within 1994-2000	HIV cases within 2001-2007	HIV cases within 2008-2013
	The whole province	3318	(100)	1,945,227	170.57	794	1743	781
1	Kermanshah	2936	88.5	1,030,978	284.78	640	1583	713
2	Islam Abad	64	1.9	151,473	42.25	21	37	6
3	Paveh	3	0.1	56,837	5.28	3	0	0
4	Javanroud	12	0.4	71,235	16.84	10	2	0
5	Dalahoo	7	0.2	39,837	17.57	7	0	0
6	Ravansar	2	0.1	46,395	4.31	2	0	0
7	Sarpol-e Zahab	17	0.5	85,616	19.86	8	5	4
8	Songhor	46	1.4	91,935	50.03	15	28	3
9	Sahneh	32	1.0	76,678	41.73	19	7	6
10	Ghasr-e Shirin	45	1.4	25,517	176.35	13	19	13
11	Kangavar	41	1.2	81,051	50.58	11	15	15
12	Gilan-e Gharb	13	0.4	62,858	20.68	7	2	4
13	Harsin	99	3.0	86,342	114.66	37	45	17
14	Salas-e Babajani	1	0.01	38,475	2.59	1	0	0

Also, suicide was the most common cause of death in 1997 (Figure 1D). It seems that the existence of this pattern in the early years was a sign of people's lack of awareness and fear of HIV, which gradually changed into dying of HIV due to carrying out needs assessments in the country over the next few years [29, 30] and training in this regard. Additionally, the findings showed that intravenous drug injection (85%) and sexual intercourse (13%) held the highest percentages in terms of infecting patients with HIV, and it is noteworthy that intravenous drug injection and sexual intercourse had downward and upward trends in recent years, respectively, whose statistics were reported the same in 2013 (Figure 1E). The reason for this change may be the third wave of AIDS (sexual contact) in Iran. The pattern of AIDS transmission in Iran, which was mainly through addiction and sharing syringes, has now changed to sexual transmission. The disease, which has undergone three waves in Iran, became initially epidemic through blood products and then through sharing syringes in prisons and rehabilitation centers, but the third wave is now due to sexual contacts [31, 32]. To explain in more detail, it can be claimed that the pattern of drug use in Iran has changed in recent years; i.e., the rate of intravenous drug injection has decreased and the use of other drugs such as ecstasy, heroin and glass has become more prevalent [33]. Furthermore, HIV transmission through sexual contacts has increased in recent years [34]. Comparing the different age groups infected with HIV showed that the 35-44 and 25-34 age groups had the highest percentages over 1995-1997 and 1998-2013, respectively (Figure 1F), i.e., the age group pattern in Kermanshah Province has changed from middle age to youth, corresponding with the national statistics [4].

Studying the trend of HIV in Kermanshah Province using GIS demonstrated that the rate of this disease has had upward trends over 20 years and the majority of HIV-stricken people (88.5%) were based in Kermanshah (284 cases per 100 000 population) (Figure 2), which is a natural trend like in other countries, but the remarkable point that should be taken into consideration here is that this increase in the HIV transmission rate was the result of the poor health status [35]. Because Kermanshah Province was among the semi-developed provinces of Iran in terms of health indexes [36], any increases in HIV rates will be a serious threat. A comparative study of the number of HIV-stricken patients reported in Kermanshah Province during the three aforementioned periods revealed that most reports were related to 2001-2007 (Table 1). It seems that the monitoring systems have well diagnosed HIV, and the adoption of preventive policies, including the distribution of free syringes to addicts after 2007, might have affected the transmission of this disease. Additionally, studying the trend of patients infected with this disease indicated that there were no reported statistics in the first (1994-2000) and second (2001-2007) periods in some townships such as Ravansar and Paveh (see Table 2). To further explain, it can be claimed that these townships are possessed of some traditional and ethnic characteristics, influencing the status of the disease.

To further study the spatial trends of HIV, the mean center and the standard deviation oval were used in the environment of GIS. The results of the standard deviation oval indicated that the spread of HIV was growing over 1994-2013, and the spread of the disease had a West-East direction in the first period, i.e., 1994-2000, which was justifiable considering the location of Kermanshah, whereas this spread drew

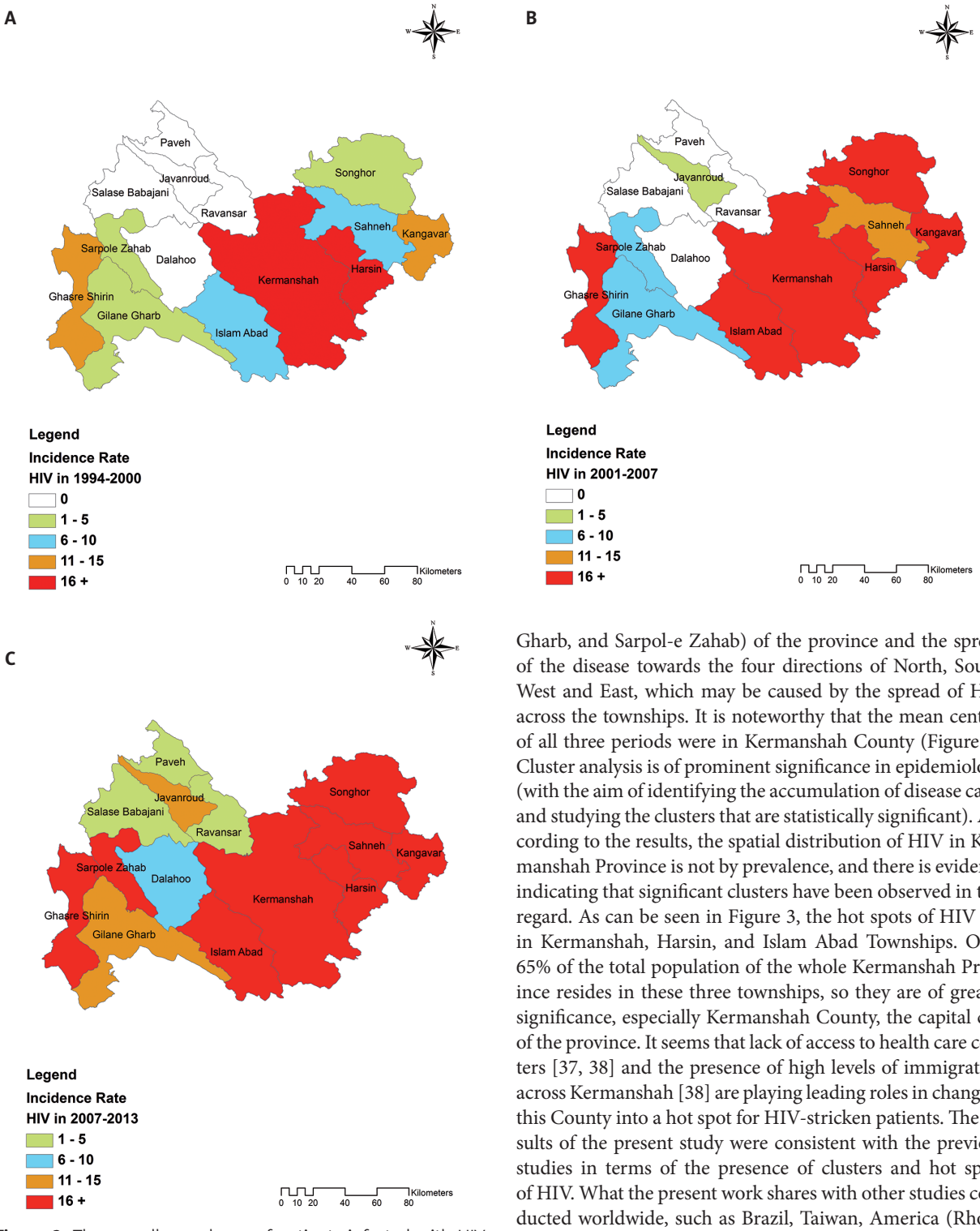

Figure 2. The overall prevalance of patients infected with HIV over three periods [1994-2000 (**A**), 2001-2010 (**B**), 2007-2013 (**C**)

Northeast-Southwest over the second period, i.e., 2001-2007. It can be claimed that this spatial trend is due to an increase of the disease across the townships based in the Northwest (Sahneh and Songhor) and Southwest (Ghasr-e Shirin, Gilan-e Gharb, and Sarpol-e Zahab) of the province and the spread of the disease towards the four directions of North, South, West and East, which may be caused by the spread of HIV across the townships. It is noteworthy that the mean centers of all three periods were in Kermanshah County (Figure 2). Cluster analysis is of prominent significance in epidemiology (with the aim of identifying the accumulation of disease cases and studying the clusters that are statistically significant). According to the results, the spatial distribution of HIV in Kermanshah Province is not by prevalence, and there is evidence indicating that significant clusters have been observed in this regard. As can be seen in Figure 3, the hot spots of HIV are in Kermanshah, Harsin, and Islam Abad Townships. Over 65% of the total population of the whole Kermanshah Province resides in these three townships, so they are of greater significance, especially Kermanshah County, the capital city of the province. It seems that lack of access to health care centers [37, 38] and the presence of high levels of immigration across Kermanshah [38] are playing leading roles in changing this County into a hot spot for HIV-stricken patients. The results of the present study were consistent with the previous studies in terms of the presence of clusters and hot spots of HIV. What the present work shares with other studies conducted worldwide, such as Brazil, Taiwan, America (Rhode Island), Africa, Russia and Iran, is the use of modern systems to detect and identify the hot spots and certain patterns of the disease [7, 19, 20, 39-45]. It is noteworthy that no modern systems have been comprehensively used yet for the diagnosis of HIV in Iran. Given the identification of the clusters of the disease across the province, one of the purposeful measures that the health policymakers can take is the continuation of studying the spatial trend of HIV across Ker-

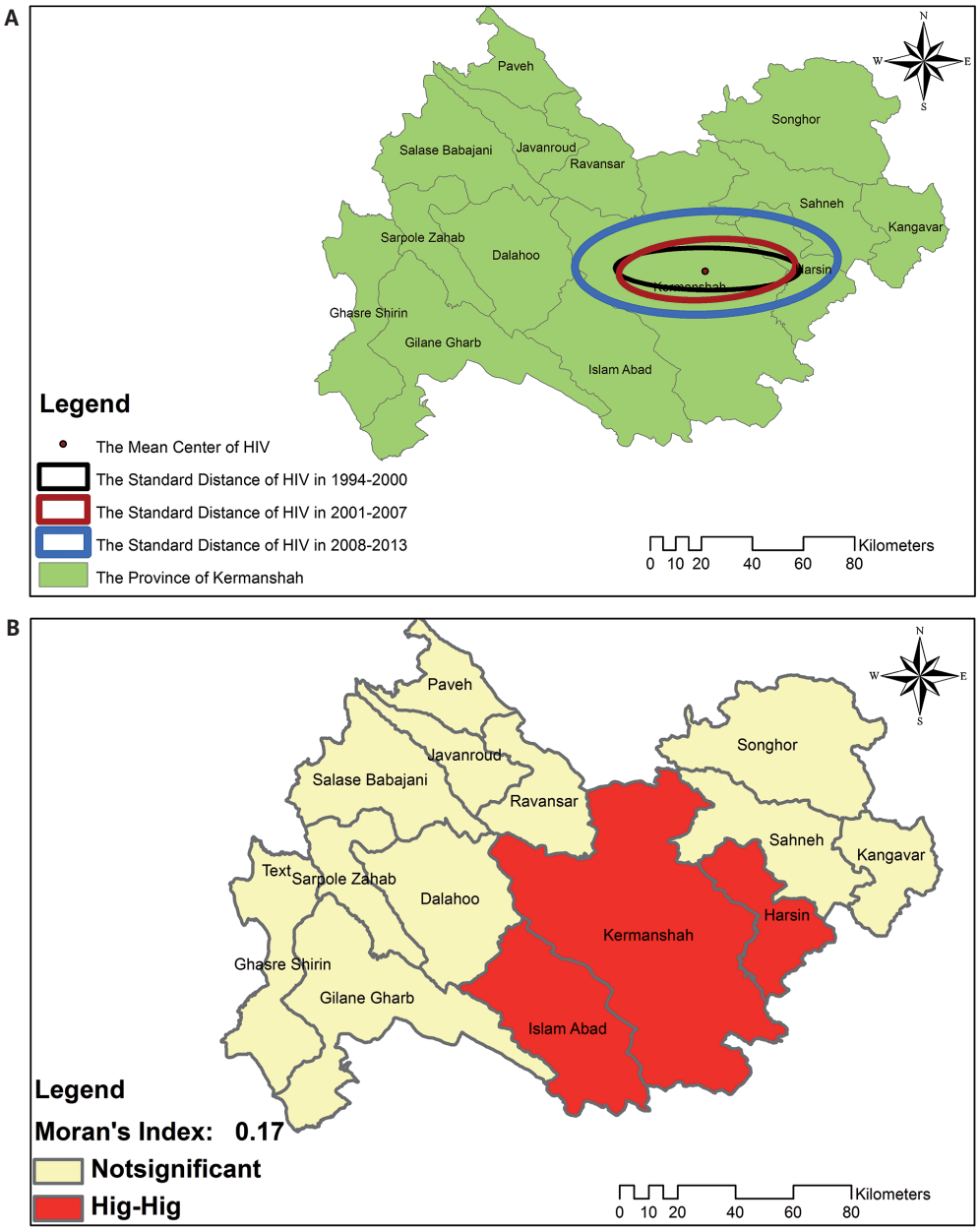

Figure 3. The mean center and standard distance (**A**) and Moran index of HIV (**B**) across Kermanshah Province.

manshah and Iran using GIS. The present study could identify the main hot spots of AIDS, high risk groups and transmission routes of this disease in Kermanshah Province. Moreover, as an effective study, the present research can help managers with future decisions and plans regarding the main hot spots of AIDS, screening at main regions of the province, defining new programs for the women's group, and paying more attention to ways of transmitting AIDS (through sex) in the province to ultimately identify more cases of the disease and prevent its growth throughout the province.

The primary limitation of the present study was the patients' incomplete and lost addresses, which made the research team exclude them from the study (missing data = 4%), which represents the fact that the data relating to such patients should be recorded precisely. On the other hand, one of the strengths of the present study was the examination of various courses of HIV's spatial expansion, and additionally the presented data could help with the purposeful prevention of HIV in the studies performed by the Public Health Headquarters.

Conclusions

The present study aimed to analyze the epidemiology and spatial trends of HIV using GIS, by which the significant geographical areas were identified in terms of the prevalence of HIV. In the past 20 years, the dominant population infect-

ed with HIV was male. However, women have had upward trends in recent years in terms of being infected with HIV. Intravenous drug injection and sexual intercourse had downward and upward trends, respectively, which were reported the same in 2013. Over the past 20 years, some changes have been observed in age groups, i.e., the majority of infected people fall into the 25-34 age group and not the 35-44 one. The prevalence of HIV in Kermanshah Province increased, and the majority of HIV-stricken people were based in Kermanshah County in a way that the spread of the disease had a west-east direction in the first period (1994-2000), in the second period (2001-2007) the spread of the disease drew northeast-southwest, and in the third period (2007-2013) it progressed in the four directions of North, South, West, and East. Furthermore, the main hot spots were based in Kermanshah, Harsin, and Islam Abad Townships. Given the weakness of the information systems and the lack of adequate data and statistics in developing countries, these results can be used by managers for planning the health practices, intervention programs in specific areas of the disease (HIV) and defining the local management plans in the area under study.

Conflict of interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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