

Inequalities in Cancer Distribution in Tehran; A Disaggregated Estimation of 2007 Incidence by 22 Districts

Marzieh Rohani Rasaf, Rashid Ramezani¹, Mitra Mehrazma², Mohamad Reza Rohani Rasaf², Mohsen Asadi-Lari²

Department of Epidemiology and Biostatistics, School of Public Health, Tehran University of Medical Sciences, ¹Cancer Department, Ministry of Health and Medical Education, ²Oncopathology Research Centre, Tehran University of Medical Sciences, Tehran, Iran

Correspondence to:

Dr. Mohsen Asadi-Lari,
Department of Epidemiology and
Biostatistics, School of Public Health,
Tehran University of Medical Sciences,
Tehran, Iran.
E-mail: asadilari@tums.ac.ir

Date of Submission: Jan 27, 2012

Date of Acceptance: Apr 22, 2012

How to cite this article: Rasaf MR, Ramezani R, Mehrazma M, Rasaf MRR, Asadi-Lari M. Inequalities in cancer distribution in Tehran; a disaggregated estimation of 2007 incidence by 22 districts. *Int J Prev Med* 2012;3:483-92.

ABSTRACT

Background: Cancer is the third cause of death in Iran, with an increasing incidence projected for the next decade. This study aimed to provide a disaggregated viewpoint on cancer incidence in all 22 districts of Tehran, using the Geographic Information System (GIS). Identifying clusters of cancers may assist in recognizing the cause of the disease, visualizing patterns of cancer distribution, the potential disparities, and help in the provision of early detection programs and equitable, curative, and palliative services.

Methods: According to the 2007 – 2008 Cancer Registry Data published by the Ministry of Health, there were 7948 new cancer cases diagnosed in Tehran. Data were collected from all pathology centers and hospitals, either public or private facilities, in Tehran. These were classified into 31 main categories according to the expert panels and available resources. The population of the districts and neighborhoods were obtained from the Iran Statistical Center and the Municipality of Tehran, respectively. Home addresses and phones were extracted from the database and imported to GIS. The Age-Standardized Rate (ASR) was calculated using both the new world standard population (2000 – 2025) and the Iran population.

Results: Overall, the cancer incidence rate and ASR were 101.8 and 94.775 per 100,000 people, respectively. The maximum cancer incidence rates in both sexes were in districts 6, 3, 1, and 2, whereas, the maximum ASRs were in districts 6, 1, 2, and 3. District 6 accommodated the highest ASRs in both the sexes. Common cancers were breast, skin, colorectal, stomach, and prostate. The ASR in men and women were 129.954 and 114.546 per 100,000 population.

Conclusion: This report provides an appropriate guide to estimate the cancer distribution within the districts of Tehran. Higher ASR in districts 6, 1, 2, and 3, warrant further research, to obtain robust population-based incidence data and also to investigate the background predisposing factors in the specified districts.

Key words: Age standardized rate, geographical information system, neighborhood cancer incidence

INTRODUCTION

Chronic diseases have come out as the most challenging problems for health systems in medium- and low-income countries.^[1] Cancer is the third cause of death in Iran,^[2,3] with an increasing incidence projected for the next decade, on account of aging, population growth, environmental hazards, and westernized lifestyle.^[4,5] Epidemiological studies on cancers are pivotal to identify incidence, type, and location of cancers.^[1] The 2008 GLOBOCAN report for Iran, estimates the ASR of new cases of cancer to be 107.3 per 100,000 population, and the most common cancers are reported to be stomach, breast, colorectal, bladder, and leukemia.^[6] Another study conducted in the Tehran Metropolis using population-based cancer registry data during 1998 – 2001, indicates the ASR as 163 in men and 141.8 per 100,000 in women. The most common reported cancers in males are stomach followed by cancers of the prostate, lung, bladder, non-Hodgkin's lymphoma, and oesophagus. In females, the most common reported cancer was breast cancer followed by cancers of stomach, lung, ovary and oesophagus.^[7] Official reports by the Iranian Ministry of Health, indicate that in Tehran, in 2007, the most common cancers in males were skin, prostate, stomach, colorectal, and bladder, and in women, they were breast, skin, colorectal, stomach, and ovary.^[8] Locations play an important role in the epidemiology of diseases. Hippocrates indicated in his memorial book, 'Airs, Waters, and Places' that: "You will find, as a general rule, that the constitutions and habits of a people follow the nature of the land where they live." The initial disease maps were produced in Germany over two hundred years ago. Then in 1855, dot maps of a cholera epidemic by John Snow became the most famous example of spatial epidemiology.^[9] The first color cancer maps were produced in 1875.^[10] Early nineteenth century research looked to geography to identify etiological clues.^[11,12] In the 1970s, the use of GIS increased among epidemiologists and public health researchers,^[13] when cancer clusters detected in near areas of high electromagnetic fields, where clusters of disease with unknown etiology regained popular attention in the late 1970s.^[14] Increased awareness of GIS has engendered new opportunities for policymakers to estimate the relationship between public health and

the geographic characteristics of residential areas.^[15,16] In cancer, epidemiology helps to produce cancer maps and spatial analysis, to investigate the potential relationships between environmental risk factors and cancers.^[17-20] Appropriate and valid information on different cancers in special geographic areas can help specific medical programs, for high-risk groups.^[21] Many studies have been conducted on cancer and environmental factors such as exposure to pesticides,^[22] residence close to a petrochemical plant,^[23] socioeconomic factors,^[24] or geographical locations; either the distribution of gastric or esophageal cancer in the Caspian region^[25,26] or clusters of breast and lung cancer incidence among residents living near a river.^[27] Colorectal cancer in the United States varies geographically, while demographics, education, behavior factors, and screening use, could only partially explain the differences across geographical divisions.^[28] Residential history as well as duration of residence may play a role in breast cancer incidence.^[29]

Various studies have investigated the cancer incidence in Tehran, either by using pathology or the population-based registry,^[30,31] however, the present study was designed to provide a disaggregated viewpoint on cancer incidence within the 22 districts of Tehran, using GIS. Identifying clusters of cancers may assist in identifying the cause of disease and visualizing patterns of cancer distribution and potential disparities, to provide early detection programs for populations at risk, as also equitable, curative, and palliative services.

METHODS

Cancer registry in Iran

There are two main cancer registry systems in the country; pathology-based, which has been endorsed by law since 1984, and population-based cancer registry, which is defined as using multiple sources (including hospital records, diagnostic facilities, and death certificates) to collect cancer data.^[1,32] Cancer registration in developing countries suffers from instability of the population, due to emigrations and mobility, lack of expert personnel, inequitable healthcare infrastructure, limited hospital facilities, and inappropriate and unreliable death certificates.^[33,34] The pathology-based cancer

registry includes cases diagnosed histologically or cytologically, which are reported regularly to the health system, then compiled, and refined to make an annual report by the Ministry of Health; this registry covered more than 81% of the incident cases in 2005, while the quality and coverage of the reported cancers by laboratories and pathology centers have been improved significantly so far.^[1,32,35]

The study area

The Tehran metropolitan area is situated on the southern slopes of the Alborz Mountains at a latitude of 35°45'N and a longitude of 51° 25'E, consisting of 22 municipal districts, with a total population of 7803883 (according to 2006 census), living in 374 neighborhoods, with a mean population of 20865.

Data collection

According to the 2007 – 2008 Cancer Registry Data published by the Ministry of Health, there were 7948 new cancer cases diagnosed in Tehran. Data were collected from all pathology centers and hospitals, either public or private facilities, in Tehran. The data on cancer cases had to include the patient's age, sex, address, and cancer type, with topology. A total of 70 different topographic reports on malignancies were reported for all cases, while these were classified into 31 main categories according to expert panels and the available resources,^[6,8] which are shown in Table 1. The population of the districts and neighborhoods was extracted from the IRAN statistical center and the municipality, respectively.

Districts and neighborhood maps in the GIS were identified by giving attention to municipal data, to convert paper maps and data into a digital format. After providing the neighborhood map, the location of cancer cases could be shown on the map that was produced.

Home addresses and phones were extracted from the database and the neighborhoods were verified by the research team. Case data that did not have sufficient information on addresses and phone numbers were eliminated.

Data analysis

In the initial step, the frequency of the 31 topographic categories was reported in

22 districts. Second, the crude incidence rate of the cancers was calculated in 14 age groups and both sexes, in a population of 100,000. The world standardized rate (ASR) per 100,000 people was calculated using the direct method of standardization to the 1966 and new (2000)^[36] World Health Organization (WHO) World Standards. Third, the neighborhood cancer incidence per 1000 people was calculated in each district. Data analysis was done by Stata v.11 and SPSS software (version 17).

Age standardized rate calculation

Most rates, such as incidence and prevalence, are strongly age-dependent, therefore age-specific comparisons are useful, but comparisons of crude age-specific rates may be misleading, because of different age structures in populations, hence, age standardization or age adjustment are recommended. The age-adjusted rates are rates that would have existed if the population under study had the same age distribution as the 'standard' population. Direct standardization yields a standardized rate, which is a weighted average of the age-specific rates for each of the populations, based on the age-independent index (standard population) to be compared. The age-adjusted rate is calculated by multiplying each crude rate by the appropriate weight (the standard), which is summed up at the end.

Both new world standard population (2000 – 2025),^[36] which reflects the average age structure of the world's population expected from the year 2000 to 2025, and also the national standard population were used for this purpose. Implementation of the new world standard population facilitates comparative analysis globally.^[8,36]

RESULTS

A total of 8246 new cancer cases were identified in 2007, in Tehran, within the mandatory pathology registry of cancers. Of these, 298 cases were excluded from our study, as their location was out of the Tehran metropolitan official borders. Out of 7948 remaining cases, 576 were unknown or with no recorded address, to identify their district of residential area, but they were included in the study to calculate the cancer incidence rates.

Table 1: Frequency, incidence, and ASR of cancer types in Tehran

Cancer types	Frequency (%)	Incidence	ASR, Iran	ASR, World 1966	ASR, World 2000
Bladder	446 (5.6)	5.715	4.465	6.557	7.378
Bone	108 (3.3)	3.406	1.327	1.394	1.342
Bone marrow	266 (3.3)	3.409	2.795	3.687	3.177
Brain and CNS	218 (2.7)	2.793	2.365	2.811	2.730
Breast	1347 (17)	17.261	12.140	17.624	17.122
Cervix and vagina*	102 (1.3)	2.671	2.156	2.831	3.084
Colorectal	762 (9.6)	9.764	7.356	10.904	9.054
Liver and gallbladder	55 (0.7)	0.705	0.551	0.810	0.619
Kidney	90 (1.1)	1.153	0.862	1.274	1.175
Larynx	132 (1.7)	1.691	1.169	1.910	1.685
Lung	247 (3.1)	3.165	2.44	3.587	2.911
Lymph node	197 (2.5)	2.524	2.155	2.466	2.334
Mediastinum, heart, and pleura	37 (0.5)	0.474	0.395	0.484	0.443
Nasal and paranasal	19 (0.2)	0.243	0.173	0.254	0.218
Lip, oral cavity, tonsils, and mouth	118 (1.5)	1.512	1.210	1.651	1.306
Ovary*	146 (1.8)	3.824	3.175	4.09	4.404
Pancreas	72 (0.9)	0.923	0.678	1.051	0.930
Peritoneum and retro-peritoneum	23 (0.3)	0.295	0.247	0.356	0.305
Pharynx	38 (0.5)	0.487	0.348	0.546	0.471
Prostate**	543 (6.8)	13.621	11.33	16.236	18.226
Parotid and salivary glands	29 (0.4)	0.372	0.309	0.384	0.336
Skin, external ear, and labia major	1293 (16.3)	16.569	12.427	19.006	15.428
Small intestine	10 (0.1)	0.128	0.096	0.145	0.127
Soft tissue	123 (1.5)	1.576	1.427	1.557	1.392
Stomach	591 (7.4)	7.573	5.903	8.525	6.608
Testis**	58 (0.7)	1.454	1.27	1.197	1.283
Thyroid	167 (2.1)	2.140	1.681	1.956	1.950
Eye and eyelid	144 (1.8)	1.847	1.395	2.1334	1.769
Uterus*	132 (1.7)	3.431	2.695	3.808	4.096
Esophagus	164 (2.1)	2.102	1.643	2.388	1.715
Unknown	268 (3.4)	3.434	2.607	3.876	3.301
Total	7945	101.808	78.037	111.591	94.775

*Only for women. **Only for men

The overall cancer incidence rate was 101.8 per 100,000 people. The mean age in males was 74, which was more than in females (70.47). The maximum cancer incidence rates between districts in both sexes were seen in districts 6, 3, 1, and 2, whereas, the maximum ASRs were in districts 6, 1, 2, and 3. The highest ASR in women was in districts 6, 22, 1, and 2, and in men it was in districts 6, 3, 1, and 2 [Table 2 and Figures 1 and 2]. Figure 3 demonstrates the distribution of incidence according to all 374 neighborhoods across Tehran, where the incidence varied between zero and 13.81 per 1000.

The incidence rate and ASR in both sexes of a total of 7948 cases were 101.8 and 94.775 per 100,000, respectively. Common cancers were breast, skin, colorectal, stomach, and prostate cancers [Table 1]. The incidence rate and ASR in 4193 men were 105.182 and 129.954 and in 3755 women they were 98.363 and 114.546 [Table 3].

Higher cancer incidence of breast, colorectal, ovary, and bone marrow cancer in females was observed in district 3, and skin and stomach cancers in districts 6 and 10, respectively. The highest rate of bladder, colorectal, prostate, and stomach cancers in males was seen in district 6.

Table 2: Frequency, incidence, and ASR of total cancers in Tehran districts

District	Frequency	Valid percent	Incidence	ASR, Iran	ASR, world 1966	ASR (New World)
1	572	7.8	150.541	91.872	136.483	150.838
2	876	11.9	143.886	88.242	131.215	143.969
3	489	6.6	168.200	88.187	129.952	142.957
4	701	9.5	85.220	67.566	103.730	114.321
5	606	8.2	89.235	68.400	107.075	119.303
6	472	6.4	198.911	111.487	162.374	177.069
7	346	4.7	111.547	64.552	101.271	110.331
8	345	4.7	91.095	56.019	87.276	95.666
9	116	1.6	69.920	46.859	79.290	86.369
10	241	3.3	76.358	48.735	77.930	86.397
11	302	4.1	109.722	71.561	118.390	129.166
12	238	3.2	95.949	61.007	104.938	114.647
13	208	2.8	84.648	55.349	88.207	95.705
14	347	4.7	71.778	50.013	84.116	92.296
15	367	5.0	56.965	49.241	80.307	88.335
16	252	3.4	86.548	52.158	97.935	108.592
17	142	1.9	55.464	37.985	65.867	71.333
18	163	2.2	51.389	47.563	78.115	85.580
19	135	1.8	54.046	50.162	81.713	90.544
20	273	3.7	81.339	64.234	103.199	113.763
21	98	1.3	61.329	49.457	81.917	90.080
22	83	1.1	76.375	71.386	124.347	137.615
Total	7372	100.0	94.466	65.431	103.494	113.747

Table 3: Frequency, incidence, and ASR of common cancers in Tehran

Gender	Common cancers	Frequency (percent)	Incidence	ASR (Iran)	ASR (World 1966)	ASR (World 2000)
Both sex	Breast	1347 (17%)	17.26	12.140	17.624	17.122
	Skin	1293 (16.3)	16.568	12.427	19.006	15.428
	Colorectal	762 (9.6)	9.764	7.356	10.904	9.054
	Stomach	591 (7.4)	7.573	5.903	8.525	6.608
	Prostate	543 (6.8)	6.958	5.645	8.382	5.922
Male	Skin	864 (20.6)	21.673	14.104	24.852	27.554
	Prostate	543 (13)	13.621	11.333	16.236	18.226
	Colorectal	420 (10)	10.535	8.603	11.712	13.042
	Stomach	415 (9.9)	10.410	8.543	11.695	13.096
	Bladder	367 (8.8)	9.206	7.582	10.502	11.837
Female	Breast	1327 (38.4)	34.761	27.503	35.473	38.622
	Skin	429 (11.4)	11.237	7.403	12.79	14.282
	Colorectal	342 (9.1)	8.958	7.164	10.046	11.042
	Stomach	176 (4.7)	4.61	3.784	5.155	5.761
	Ovary	146 (3.9)	3.824	3.175	4.095	4.404

For further analysis, the cancer types were limited to five most common cancers [Table 3], which were significantly different within districts; found by using the Fisher exact test ($P < 0.001$).

Age-specific rates of the five common malignancies among men are presented in Figure 4;

the prostate cancer rate starts in the fourth and increases sharply in the sixth decade of life. In women, the breast cancer rate presents a different age-specific pattern [Figure 5], which increases between the ages of 30 and 65, and then it comes to recess.

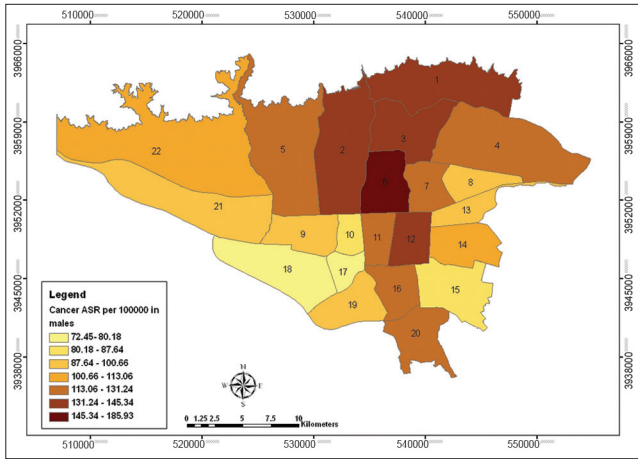


Figure 1: Cancer ASR per 100000 in men in the 22 districts of Tehran

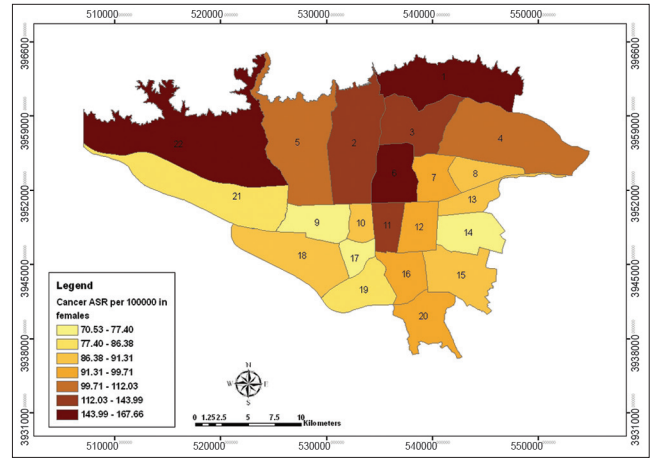


Figure 2: Cancer ASR per 100000 in women in the 22 districts of Tehran

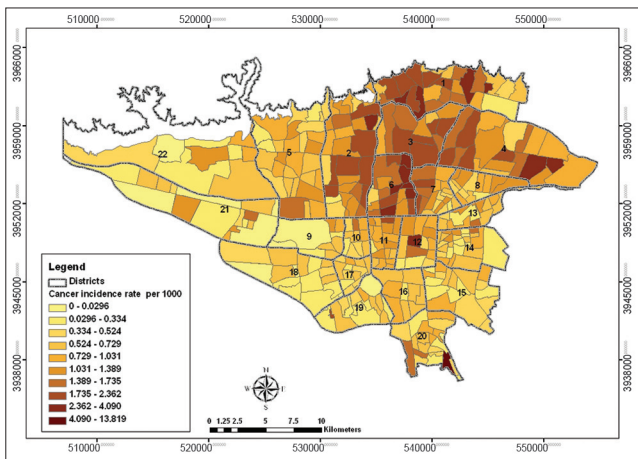


Figure 3: Cancer incidence per 1000 in the neighborhoods of Tehran

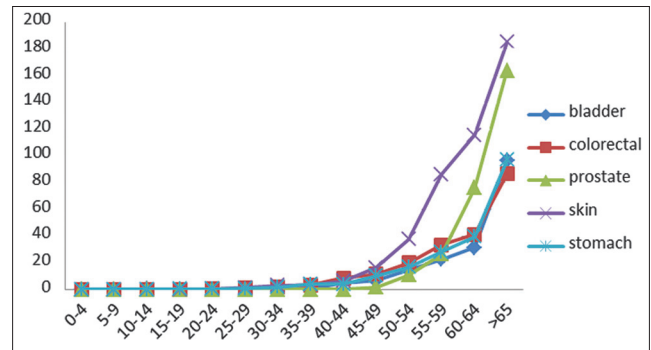


Figure 4: Trend of age-specific incidence rate in men

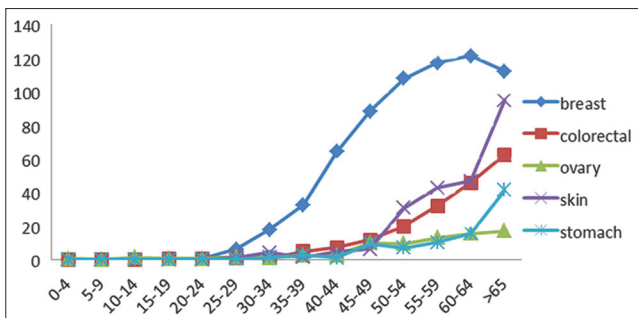


Figure 5: Trend of age-specific incidence rate in women

DISCUSSION

This is the first report of district-based cancer incidence in Tehran, which demonstrates differences in cancer incidence in all 22 districts of Tehran. The previous report indicated the

overall cancer incidence in the metropolitan area, although it was a population-based report, which included all data sources.^[7] The overall cancer ASR in Tehran was 94.775, with a breakdown to prostate (18.22), stomach (13.09), colorectal (13.04), and bladder (11.83) in men, and breast (38.62), colorectal (11.04), stomach (5.76), and ovary (4.4) in women. The highest cancer ASR in women was seen in districts 6, 22, 1, and 2, and in men it was seen in districts 6, 3, 1, and 2. The higher ASR in district 22 compared to the other districts was due to the higher age-specific rate of total cancer after age 65. The mean age of cancer in men was greater than in women.

A study on childhood cancer in the inner city of the Tehran metropolitan indicated that cancer incidence in youngsters (less than 15 years) were seen in districts 6, 12, 7, 4, and 18, and the lowest incidence among both sexes was observed in district 21.^[31] In this study, the higher incidence in

less than 15-year patients was seen in districts 7, 8, 6, 12, and 19, and the lowest incidence was in district 22.

Cancer incidence rate in women and men was 98.363 and 105.182. It was adjusted by the standard world population (1966) to compare with other studies. In this study, the total cancer ASR in women and men was 104.902 and 117.535, respectively, while the Iranian Ministry of Health had reported the overall ASR in Tehran, in 2007, as being 99.89 and 99.05 for women and men, which was less than the figures reported for 2006.^[8] During 1998 – 2001, in Tehran, stomach, lung, and esophageal cancers were the most common malignancies in women and men, while those in this study and in report 2007 of the Ministry of Health has decreased dramatically. Indeed all cancers have diminished, except breast in women, since 1998 – 2007.^[7,8] In a retrospective study, in the breast cancer cases in five provinces covered by the cancer registry, during the five-year period, 1996 – 2000, breast cancer ASR was 16.2 while during 1998 – 2001 the ASR in Tehran was 31.4. Breast cancer ASR in this study (adjusted by 1966 population) was 35.47, thus, it could be concluded that the incidence of breast cancer has increased in Tehran.^[37] The ASR of breast cancer in Iran was lower than in the developed countries, but it had the highest cancer incidence in Iranian women.^[8] The 2008 GLOBOCAN report estimated the ASR of breast cancer to be 29.3 for EMRO and 18.4 for Iran.^[6]

In a study based on the population cancer registry in the five provinces of Iran, the ASR of colorectal cancer (CRC) in males and females was 8.2 and 7,^[38] which was less than our findings in Tehran, which were, 11.7 and 10, respectively. The CRC ASR sex ratio was 1.4 : 1 in the world,^[6] compared to 1.17 in both Ansari *et al.*'s study^[38] and the present study. In the previous report of CRC epidemiology in Iran, 17^[38] and 42.90%^[39] of the cases were under 40 and 50 years, respectively, while in this study 6.5 and 19.68% of the CRC were under 40 and 50 years, and then steeply increased to over 65-year-old men. According to these findings, CRC presents in older age in Tehran, which warrants further studies, such as, age-period cohort, to investigate the grounded reasons for this age distribution. This age proportion was similar to proportions seen in

many other Middle-Eastern countries,^[38] but much higher than in Western countries, for example, 8.7% of the total CRC patients were under 50 years old in the United States.^[40] This is probably due to the younger age-structure of our country and relatively low rates of CRC in older individuals. Having said that, when age-adjusted rates were calculated, these figures were almost the same in both Iran and the western countries,^[38] which could be a clear reason against the early onset of CRC in Iran. Genetic factors have claimed to play a role in the development of CRC at a younger age,^[38,39] however, there is insufficient evidence to prove the early onset of CRC in Iran, due to the fact that age-adjusted rates are close to their western counterparts. The ASR of male CRCs in Tehran was higher than in Pakistan and Turkey, the neighboring countries,^[41,42] and was higher than in females, which was probably due to more prevalence of inflammatory bowel disease (IBD) in males.^[43]

The ASR of cervix cancer in Tehran was 2.83, which was lower than in Pakistan (6.5) and Turkey (5.4), the neighboring countries.^[41,42] Ovarian cancer ASR rate in this study was 4.09, which was similar to the national figure (4.25)^[8] and less than the previous report in Tehran during 1998 – 2001 (6.5),^[7] and much less than in the US, which was asserted to be attributable to the vast use of oral contraceptives, higher parity, reduced energy intake, and also shortages in the cancer registry in Iran.^[44]

Thyroid cancer had a total ASR of 1.95, and was much greater in females (2.88) than in males (1.07), which was almost similar to other reports where the female to male ratio has been reported to be 3.^[45,46]

There are some limitations in this study. Although the quality of pathological data in Tehran is fairly acceptable, one may claim otherwise.^[47] This is mainly because the Pathology Department must rely upon such data that are filled in, almost invariably rather poorly, by busy clinicians, who are reluctant to supply data, which may not be at hand (e.g., in the Operating Room), and which they feel is unnecessary or irrelevant.^[33] Therefore, the population-based cancer registries are widely recommended,^[1] which may prevail pathology-based registry, particularly in stomach and lung cancers that are usually diagnosed in

advanced stages and with high-case fatality rates, and therefore, may underestimate the true cancer rates. However, the quality of the pathology-based registry has improved constantly and significantly from 27% in 1973^[48] to a so-called 86.7% in 2007;^[49] the validity of national reports should be approved by the third party, although the figures of most incidences — highly fatal cancers like lung, liver, and stomach — are close to what GLOBOCAN^[6] had predicted for Iran.

The second limitation refers to the incomplete and missing addresses, which pushed the research team to either investigate the surrogates such as telephone codes or path finding through maps or even discard them from the study if no address was found. This may have some implications in the proper estimation of cancer incidence. Nevertheless, the purpose of this study was to show inequalities in cancer incidence within the districts of Tehran, where all limitations probably occur similarly. Despite these limitations, this is the first report of cancer incidence within the districts of Tehran that provides a useful guide to evaluate the cancer control program. Higher incidence rate in defined districts warrants further investigations for possible risk factors.

REFERENCES

1. Parkin DM. The evolution of the population-based cancer registry. *Nat Rev Cancer* 2006;6:603-12.
2. Gouya M. Iranian Annual Cancer Registration Report 2005/2006. Tehran: Ministry of Health and Medical Education, Deputy for Health, Center for Disease Control and Prevention; 2007.
3. Naghavi M, Abolhassani F, Pourmalek F, Lakeh M, Jafari N, Vaseghi S, *et al.* The burden of disease and injury in Iran 2003. *Popul Health Metr* 2009;7:9.
4. Jemal A, Bray F, Center MM, Ferlay J, Ward E, Forman D. Global cancer statistics. *CA Cancer J Clin* 2011;61:69-90.
5. Mousavi SM, Gouya MM, Ramazani R, Davanlou M, Hajsadeghi N, Seddighi Z. Cancer incidence and mortality in Iran. *Ann Oncol* 2009;20:556-63.
6. GLOBOCAN IARC. Cancer Incidence and Mortality Worldwide in 2008. Lyon: International Agency for Research on Cancer, WHO; 2008.
7. Mohagheghi MA, Mosavi-Jarrahi A, Malekzadeh R, Parkin M. Cancer incidence in Tehran metropolis: The first report from the Tehran Population-based Cancer Registry, 1998-2001. *Arch Iran Med* 2009; 12:15-23.
8. IRAN CDC. Iran Cancer Registration Report, 2006. Tehran: Ministry of Health and Medical Education, Centre for Disease Control; 2010.
9. Snow J. On the Mode of Communication of Cholera. London, UK: John Churchill; 1855.
10. Haviland A. Geographical Distribution of Heart Disease and Dropsy, Cancer in Females and Phthisis in Females, in England and Wales. London, UK: Smith, Elder; 1875.
11. Krieger N. Epidemiology and social sciences: Towards a critical reengagement in the 21st century. *Epidemiol Rev* 2000;11:155-63.
12. Mcleod KS. Our sense of Snow: The myth of John Snow in medical geography. *Soc Sci Med* 2000; 50:923-35.
13. Walter S. Disease mapping: A historical perspective. In: Elliott P, Best N, editors. *Spatial Epidemiology: Methods and Applications*. 1st ed. New York: Oxford University Press; 2001.
14. Brodeur P. Currents of death: Power lines, computer terminals, and the attempt to cover up their threat to your health. New York: Simon and Schuster; 1989.
15. Morra P, Bagli S, Spadoni G. The analysis of human health risk with a detailed procedure operating in a GIS environment. *Environ Int* 2006;32:444-54.
16. Pearce J, Boyle P. Examining the relationship between lung cancer and radon in small areas across Scotland. *Health Place* 2005;11:275-82.
17. Elliott P, Wakefield J, Best N, *et al.* *Spatial epidemiology: Methods and applications*. In: Elliott P, Best N, editors. *Spatial Epidemiology: Methods and Applications*. New York: Oxford University Press; 2001.
18. Flinton DM, Walters NJ. Occupational activity and risk of prostate cancer in Ireland. *J Radiother Pract* 2004;4:102-6.
19. Pickle LW, Waller LA, Lawson AB. Current practices in cancer spatial data analysis: A call for guidance. *Int J Health Geogr* 2005;4:3.
20. Roche LM, Skinner R, Weinstein RB. Use of a geographic information system to identify and characterize areas with high proportions of distant stage breast cancer. *J Public Health Manag Pract* 2002; 8:26-32.
21. Babaei M, Mousavi S, Malek M, Tosi G, Masoumeh Z, Danaei N, *et al.* Cancer occurrence in Semnan Province, Iran: Results of a population-based cancer registry. *Asian Pac J Cancer Prev* 2005;6:159-64.
22. Brody JG, Aschengrau A, McKelvey W, Rudel RA, Swartz CH, Kennedy T. Breast cancer risk and historical exposure to pesticides from wide-area

- applications assessed with GIS. *Environ Health Perspect* 2004;112:889-97.
23. Belli S, Benedetti M, Comba P, Lagravinese D, Martucci V, Martuzzi M, *et al.* Case-control study on cancer risk associated to residence in the neighborhood of a petrochemical plant. *Eur J Epidemiol* 2004; 19:49-54.
 24. Ng E, Wilkins R, Fung MF, Berthelot JM. Cervical cancer mortality by neighborhood income in urban Canada from 1971 to 1996. *CMAJ* 2004;170:1545-9.
 25. Mohebbi M, Mahmoodi M, Wolfe R, Nourijelyani K, Mohammad K, Zeraati H, *et al.* Geographical spread of gastrointestinal tract cancer incidence in the Caspian Sea region of Iran: Spatial analysis of cancer registry data. *BMC Cancer* 2008;8:137.
 26. Mohebbi M, Wolfe R, Jolley D, Forbes AB, Mahmoodi M, Burton RC. The spatial distribution of esophageal and gastric cancer in Caspian region of Iran: An ecological analysis of diet and socio-economic influences. *Int J Health Geogr* 2011;10:13.
 27. Guajardo OA, Oyana TJ. A critical assessment of geographic clusters of breast and lung cancer incidences among residents living near the Tittabawassee and Saginaw Rivers, Michigan, USA. *J Environ Public Health* 2009;2009:1-16.
 28. Lai SM, Zhang KB, Uhler RJ, Harrison JN, Clutter GG, Williams MA. Geographic variation in the incidence of colorectal cancer in the United States, 1998-2001. *Cancer* 2006;107:1172-80.
 29. Vieira VM, Webster TF, Weinberg JM, Aschengrau A. Spatial-temporal analysis of breast cancer in upper Cape Cod, Massachusetts. *Int J Health Geogr* 2008;7:46.
 30. Larijani B, Shirzad M, Mohagheghi MA, Haghpanah V, Mosavi-Jarrahi AR, Tavangar SM, *et al.* Epidemiologic analysis of the Tehran Cancer Institute Data System Registry (TCIDSR). *Asian Pac J Cancer Prev* 2004; 5:36-9.
 31. Mosavi-Jarrahi A, Moini M, Mohagheghi MA, Alebouyeh M, Yazdizadeh B, Shahabian A, *et al.* Clustering of childhood cancer in the inner city of Tehran metropolitan area: A GIS-based analysis. *Int J Hyg Environ Health* 2007;210:113-9.
 32. Etemadi A, Sadjadi A, Semnani S, Nouraie SM, Khademi H, Bahadori M. Cancer registry in Iran: A brief overview. *Arch Iran Med* 2008;11:577-80.
 33. Parkin DM, Sanghvi LD. Cancer registration in developing countries. In: Jensen OM, Parkin DM, Maclennan R, Muir CS, Skeet RG. editors. *Cancer Registration: Principles and Methods*. Lyon, France: IARC Scientific Publications; 1991.
 34. Valsecchi MG, Steliarova-Foucher E. Cancer registration in developing countries: Luxury or necessity? *Lancet Oncol* 2008;9:159-67.
 35. Akbari M, Abachizadeh K, Khayamzadeh M. Iran cancer report. Ghom, Iran: Darolfekr Publication; 2007.
 36. Ahmad OB, Boschi-Pinto C, Lopez AD, Murray CJL, Lozano R, Inoue M. Age standardization of rates: A new WHO standard. *GPE Discussion Paper Series: No.31*. Geneva EIP/GPE/EBD: Geneva: World Health Organization; 2009.
 37. Sadjadi A, Nouraie M, Ghorbani A, Alimohammadian M, Malekzadeh R. Epidemiology of breast cancer in the Islamic Republic of Iran: First results from a population-based cancer registry. *East Mediterr Health J* 2009;15:1426-31.
 38. Ansari ., Mahdavinia M, Sadjadi A, Nouraie M, Kamangar F, Bishehsari F, *et al.* Incidence and age distribution of colorectal cancer in Iran: Results of a population-based cancer registry. *Cancer Lett* 2006;240:143-7.
 39. Safaee A, Moghimi-Dehkordi B, Fatem SR, Pourhoseingholi MA, Ghiasi S, Zali MR. Colorectal cancer in Iran: An epidemiological study. *Asian Pac J Cancer Prev* 2008;9:123-6.
 40. Shellnut JK, Wasvary HJ, Grodsky MB, Boura JA, Priest SG. Evaluating the age distribution of patients with colorectal cancer: Are the United States Preventative Services Task Force guidelines for colorectal cancer screening appropriate? *Dis Colon Rectum* 2010;53:5-8.
 41. Bhurgri Y, Bhurgri A, Hassan SH, Zaidi SH, Rahim A, Sankaranarayanan R, *et al.* Cancer incidence in Karachi, Pakistan: First results from Karachi Cancer Registry. *Int J Cancer* 2000;85:325-9.
 42. Fidaner C, Eser SY, Parkin DM. Incidence in Izmir in 1993-1994: First results from Izmir Cancer Registry. *Eur J Cancer* 2001;37:83-92.
 43. Söderlund S, Granath F, Broström O, Karlén P, Löfberg R, Ekblom A, *et al.* Inflammatory bowel disease confers a lower risk of colorectal cancer to females than to males. *Gastroenterology* 2010;138:1697-703.
 44. Arab M, Khayamzadeh M, Tehranian A, Tabatabaefar M, Hosseini M, Anbiaee R, *et al.* Incidence rate of ovarian cancer in Iran in comparison with developed countries. *Indian J Cancer* 2010;47:322-7.
 45. Larijani B, Mohagheghi MA, Bastanhagh MH, Mosavi-Jarrahi AR, Haghpanah V, Tavangar SM, *et al.* Primary thyroid malignancies in Tehran, Iran. *Med Princ Pract* 2005;14:396-400.
 46. Ron E, Schneider A. Thyroid cancer. In: Schottenfi ED, Fraumeni J. *Cancer Epidemiology and Prevention*. 3rd ed. New York: Oxford University Press; 2006.
 47. Zendehdel K, Sedighi Z, Hassanloo J, Nahvijou A. Improving quality of cancer registration in Iran. Part I:

- Evaluation and comparison of cancer registration results in the country. *Hakim (Persian)* 2010;12:42-9.
48. Mahboubi E, Kmet J, Cook PJ, Day NE, Ghadirian P, Salmasizadeh S. Oesophageal cancer studies in the Caspian Littoral of Iran: The Caspian cancer registry. *Br J Cancer* 1973;28:197-214.
49. IRAN CDC. Iran Cancer Registration Report, 2008. Tehran: Ministry of Health and Medical Education, Centre for Disease Control; 2011.

Source of Support: Tehran University of Medical Sciences,
Conflict of Interest: None declared.