Original Article

Completeness and Underestimation of Cancer Mortality Rate in Iran: A Report from Fars Province in Southern Iran

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Abstract

Background: The incidence and mortality rates of cancer are increasing worldwide, particularly in the developing countries. Valid data are needed for measuring the cancer burden and making appropriate decisions toward cancer control. We evaluated the completeness of death registry with regard to cancer death in Fars Province, I. R. of Iran.

Methods: We used data from three sources in Fars Province, including the national death registry (source 1), the follow-up data from the pathology-based cancer registry (source 2) and hospital based records (source 3) during 2004 – 2006. We used the capture-recapture method and estimated underestimation and the true age standardized mortality rate (ASMR) for cancer. We used log-linear (LL) modeling for statistical analysis.

Result: We observed 1941, 480, and 355 cancer deaths in sources 1, 2 and 3, respectively. After data linkage, we estimated that mortality registry had about 40% underestimation for cancer death. After adjustment for this underestimation rate, the ASMR of cancer in the Fars Province for all cancer types increased from 44.8 per 100,000 (95% CI: 42.8 – 46.7) to 76.3 per 100,000 (95% CI: 73.3 – 78.9), accounting for 3309 (95% CI: 3151 – 3293) cancer deaths annually.

Conclusion: The mortality rate of cancer is considerably higher than the rates reported by the routine registry in Iran. Improvement in the validity and completeness of the mortality registry is needed to estimate the true mortality rate caused by cancer in Iran.

Keywords: Cancer, completeness, Fars province, Iran, mortality

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Introduction

Efficient cancer and death registration systems form the fundamental infrastructure of cancer control programs[1] and provide important information for policy making, program planning and monitoring, resource allocation, and priority setting.[2] There is an absence of functional cancer registries in several low- and middle-income countries, including Iran.[3,4] In addition to the cancer registry, data from the death registry could provide important information regarding the cancer control status. Although vital statistics and death registries exist in several developed and developing countries, low- and middle-income countries lack valid data on the causes of death.[5,6] Therefore, the knowledge of distribution and determinants of death is lacking in developing countries.[7]

Several methods exist for determining the validity of the causes of death in death registries; among these the "verbal autopsy" or systematic retrospective inquiry of family members about the symptoms and signs of illness prior to death has been commonly used. In addition, data linkage between the cancer registry and external databases in the UK and US has allowed researchers to evaluate the validity and accuracy of the cancer death records.[8,9]

A few studies have evaluated the completeness or coverage of death registration in total, and based on different causes of death.[5,10,11] In spite of several cancer registry activities in Iran,[12–17] only Golestan Province cancer registry has been sustained for a reasonable time and was published in the 10th revision of IARC monograph "Cancer in Five Continents" in 2013.[18] Golestan province is located at the western end of Central Asian Esophageal Cancer Belt, an area that extends from the Caspian Sea through Central Asia and Mongolia to northern China.[19] This registry covers a small population in the northern Iran and the results from this registry cannot represent the Iranian population. Therefore, due to lack of validated population-based cancer registries in Iran, cancer statistics are overshadowed by several uncertainties; consequently, the true incidence and mortality rate of cancer remain unknown.[4]

Application of the capture–recapture method was suggested as the standard approach to evaluate the completeness of registries and estimate the true incidence rates of diseases such as cancer.[20,21] However, this method has not yet been used to estimate the completeness of the mortality registry. In this study, we used a three-source capture–recapture method and studied the completeness of the death registry along with an estimation of the true mortality rates of cancer, in total and for common cancer types, in Fars Province.

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Materials and Methods

This study was conducted in Fars Province, located in southern Iran; a large area with a population of 4,336,878. The 10 most common cancers, including stomach, esophageal, colorectal, lung, bladder, prostate, breast, ovarian, cervical, and endometrial cancers were selected from different databases in Fars province including 1) Mortality Registry, 2) Pathology-Based Cancer Registry and 3) Hospital Records.

Three data sources were selected to use the capture–recapture method and estimate the true number of cancer deaths and the mortality rate for different cancer types in a population of 13,309. Because we needed at least three independent data sources to apply the capture–recapture method, we used data from the Fars province death registry and two additional independent data sources that accounted for cancer deaths in the province. The additional sources included the cancer mortality data created from the follow-up of pathology-based cancer registry data and follow-up of the hospital cancer records. The subsequent paragraph describes the three data sources in detail.

Fars Province Death Registry

The Deputy of Health in the Shiraz University of Medical Science compiles the death records and information on the causes of death in the entire Fars Province with 1941 cases. Subsequently, data are sent to the Ministry of Health of Iran to report the national cause-specific mortality rates. In the current study, we used data from 2004 to 2006, since the mortality rate has been published in this period and comprehensive data were available for analysis. The death registry of Fars Province collected data from 21 cities, including the capital city of Shiraz. The registry collects different variables including sex, date of death, causes of death, and place of residence. The mortality data are then coded based on the cause. We restricted our analyses to the death records coded as cancer death. We selected the 10 most common cancers; however, we excluded hematologic malignancies because of the difficulties in specifying cancer types in the death registry.

Follow-up of cancer patients from a pathology-based cancer registry

The pathology-based cancer registry was established in Fars Province in 1998. It collects cancer data from patients who are referred for microscopic verification from different laboratories in the province. The Shiraz cancer registry is not a population-based registry and is restricted to cases undergoing surgery. Tumor tissues or biopsies are sent to the pathology department. The Shiraz pathology registry records approximately 5000 cancer cases from the entire province each year. We obtained electronic data from the Fars province cancer registry between 2001 and 2006. The cancer registry included different types of cancers along with the patients' contact information. We contacted patients or their next-of-kin and obtained information on the vital status of the patients. Those who had died during 2004 – 2006 were included in a database and used as a data source for the capture–recapture method.

Follow-up of cancer patients from the hospital records

The Shiraz cancer registry is a pathology-based registry and patients with an advanced tumor who are generally diagnosed clinically may not be registered in this cancer registry. Therefore, we performed a survey and collected cancer cases that were hospitalized with a cancer diagnosis between 2001 and 2006 in different hospitals of the province. First, we contacted all hospitals in Fars province and collected data from 16 hospitals that had diagnostic or treatment facility for cancer patients including both private and governmental hospitals from different cities of Shiraz. Information on 10 common cancers was manually collected from the hospital records. After excluding the duplicates, we followed up these patients through telephone interviews with the patients or their next-of-kin. Those who died of cancer between 2004 and 2006 formed the third data source for the capture–recapture analyses.

Statistical Analysis

Following the elimination of duplicates from each of the three data sources and patients who resided outside of Fars province, we performed a data linkage using the Microsoft Office Excel. The criteria for linkage was sharing six variables including names, family name, father's name, age, date of birth, and place of residence. In Farsi, names, family name or father names may be spelled slightly different in various databases. For names and family names that had small differences, we considered the age, date of birth or place of residence and if the information for the above mentioned variables were similar, we considered them as a unique patient and merged their information. We performed statistical analyses for the 10 most common cancers including stomach, esophageal, colorectal, lung, bladder, prostate, breast, ovarian, cervical, and endometrial cancers, as well as all cancers combined.

The capture-recapture method and log-linear modeling were used to estimate the total number of mortality rates of common cancers in Fars Province. The use of the capture–recapture method requires two or three data sources. Two important assumptions need to be met prior to use of this method, including independence of the data sources and equal accessibility to the data. However, for our statistical analyses we used log-liner modeling in which these assumptions are not essential.[22] Observed numbers of separate or combined sources were entered in the model for making capture- recapture model. Source dependence was modeled by adding the interaction term to the model. In total, we run eight models based on the three data sources (Table 1).

A confidence interval (CI) for the estimated number of cases was computed via the profile likelihood method. Baysian **(**BIC) and Akaike (AIC) Information Criterion were used for model selection. For the log-linear model the value for this criterion is AIC, and the model with the smallest AIC is selected as the best model.[23,24]

Following the estimation of the under-reported rate of cancer death, in total and in the five-year age strata, we estimated the corrected mortality rates for the all types of cancers and common cancers. We used the age distribution of the world standard population to estimate the age standardized mortality rates. STATA software (version 9) was used for statistical analyses.

Result

We observed 1969 cancer deaths recorded in the Fars Province death registry (source 1) between 2004 and 2006. After removing the duplicates, an overall 1941 cancer deaths from mortality registry database remained for analysis. In addition, after data linkage and follow-up of the patients from pathology-based cancer registry (Source 2) and hospital records (Source 3), and excluding the patients who had no contact information, resided in other

Table 1. Source dependence was modeled by adding the interaction term to the model

Model Number	Formula	Explanation
Model 1	$\mu_{ijk}=\lambda+\lambda_i^{s1}+\lambda_j^{s2}+\lambda_k^{s3}$	All the source independently in model
Model 2	$\mu_{ijk}=\lambda+\lambda_i^{s1}+\lambda_j^{s2}+\lambda_k^{s3}+\lambda_{ik}^{s1s3}$	All the source independently in model and interaction of s1 and s3
Model 3	$\mu_{ijk}=\lambda+\lambda_i^{s1}+\lambda_j^{s2}+\lambda_k^{s3}+\lambda_{ij}^{s1s2}$	All the source independently in model and interaction of s1 and s2
Model 4	$\mu_{ijk}=\lambda+\lambda_i^{s1}+\lambda_j^{s2}+\lambda_k^{s3}+\lambda_{ij}^{s3s2}$	All the source independently in model and interaction of s3 and s2
Model 5	$\mu_{ijk}=\lambda+\lambda_i^{s1}+\lambda_j^{s2}+\lambda_k^{s3}+\lambda_{ij}^{s1s2}+\lambda_{ik}^{s1s3}$	All the source independently in model and interaction of s1 & s2 and s1&s3
Model 6	$\mu_{ijk}=\lambda+\lambda_i^{s1}+\lambda_j^{s2}+\lambda_k^{s3}+\lambda_{ij}^{s3s2}+\lambda_{ik}^{s1s3}$	All the source independently in model and interaction of s3 & s2 and s1&s3
Model 7	$\mu_{ijk}=\lambda+\lambda_i^{s1}+\lambda_j^{s2}+\lambda_k^{s3}+\lambda_{ij}^{s3s2}+\lambda_{ik}^{s1s2}$	All the source independently in model and interaction of s3 &s2 and s1&s2
Model 8	$\mu_{ijk}=\lambda+\lambda_i^{s1}+\lambda_j^{s2}+\lambda_k^{s3}+\lambda_{ij}^{s3s2}+\lambda_{ik}^{s1s2}+\lambda_{ik}^{s1s3}$	All the source independently in model and interaction of s3 &s2 and s1&s2

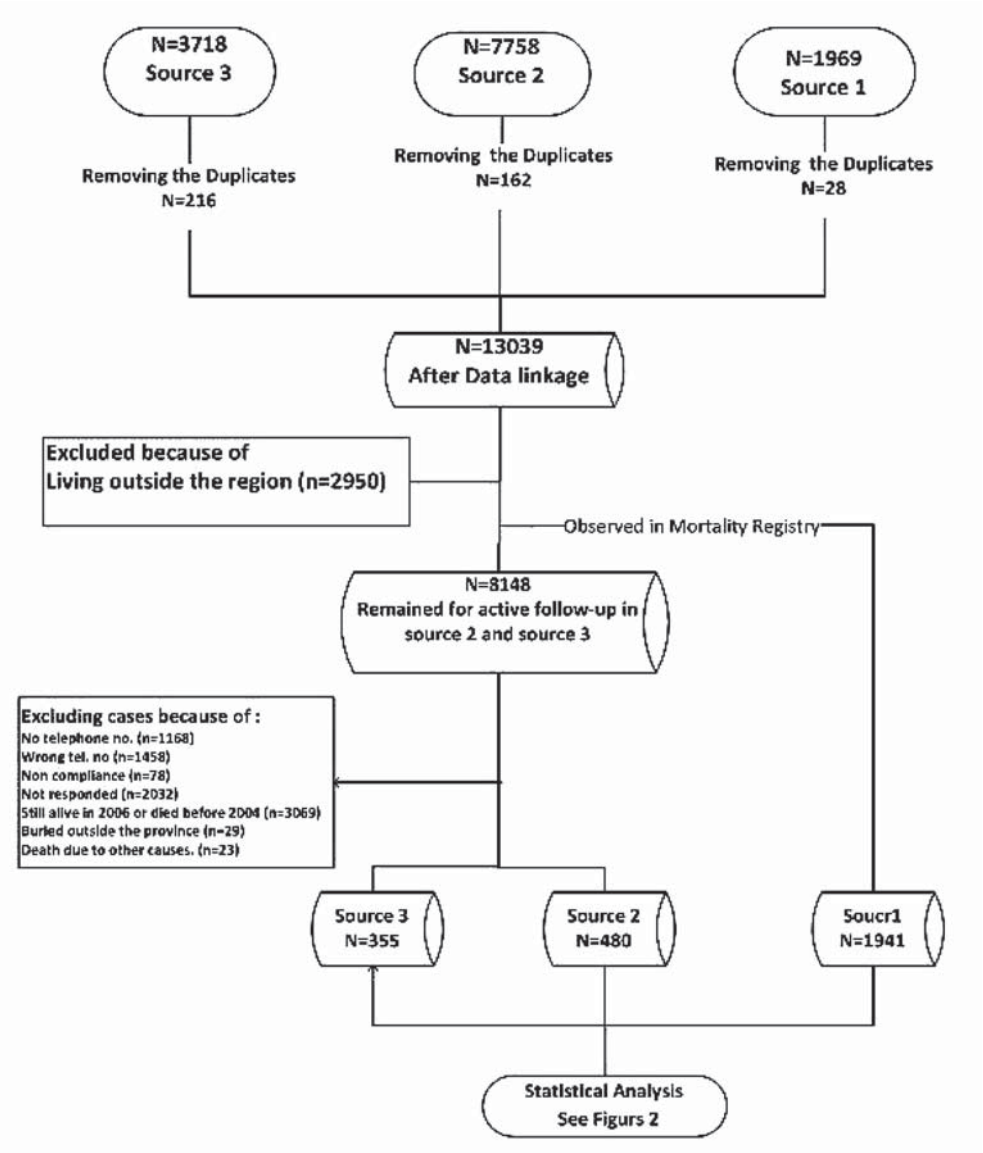

Figure 1. Flowchart of the record linkage from the data sources for using capture-recapture method and evaluate true mortality rate of cancer in Fars Province in the southern Iran in 2004–2006. **Source 1:** Mortality registry; **Source 2:** Follow-up of pathology based cancer registry; **Source 3:** Follow-up of Hospital data

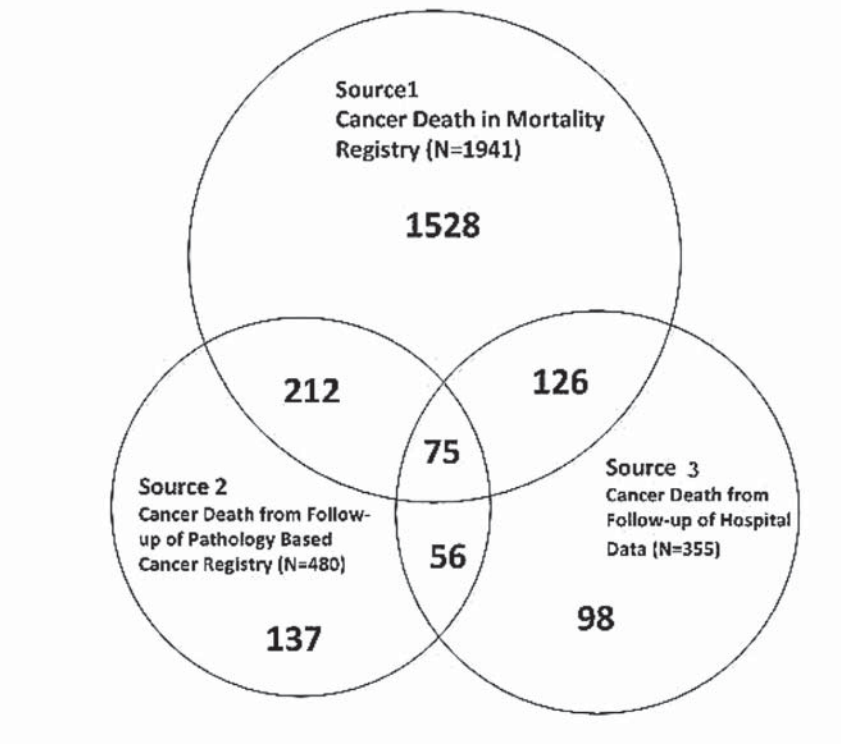

Figure 2. Venn diagram, presenting number of cancer death observed in the three data sources independently and in common with the other in Fars province in the southern Iran in 2004–2006

Table 2. Characteristics of patients who died of cancer between 2004 and 2006 in Fars Province, reported from the mortality registry (source1), and collected from the follow-up of the pathology-based cancer registry (source2) and hospital records (source3) in overall and by sex , age and the place of residence

Data Source	Overall Number	Sex*, Number (%)		Age Group (years)*, Number (%)				Place of residence*, Number (%)	
		Male	Female	25–0	50–26	65–51	Up to 65	Shiraz City	Other cities
Source1	1528	989 (64.7)	539 (35.3)	32 (2.0)	204 (13.3)	337 (22)	950 (62.1)	530 (34.6)	997 (65.2)
Source2	137	75 (54.7)	61 (44.5)	3 (2.2)	16 (11.7)	16 (11.7)	100 (73.0)	73 (53.3)	62 (45.7)
Source3	98	54 (55.1)	43 (43.9)	3 (3.1)	12 (12.2)	21 (21.4)	45 (45.9)	57 (58.2)	41 (41.8)
Source1&2	212	142 (67.0)	69 (32.6)	3 (1.4)	34 (16.0)	51 (24.1)	123 (58.0)	95 (44.8)	115 (54.2)
Source1&3	126	67 (53.2)	59 (46.8)	1 (0.8)	30 (23.8)	31 (24.6)	57 (45.2)	74 (58.7)	52 (41.3)
Source2&3	56	33 (58.9)	21 (37.5)	0 (0.0)	13 (23.2)	22 (39.3)	11 (19.6)	39 (69.6)	17 (30.4)
Source1,2&3	75	26 (34.7)	49 (65.3)	2 (2.7)	20 (26.7)	23 (30.6)	30 (40.0)	35 (46.6)	40 (53.3)
All Sources Combined	2232	1386 (62.1)	841 (37.7)	45 (2.0)	329 (14.7)	501 (22.5)	1316 (59.0)	904 (40.5)	1324 (59.3)

*Because of missing information on age, sex, and residential places, the sum of percentages does not add up to 100%.

provinces etc., we found 480 and 355 cancer deaths from Source 2 and Source 3, respectively (Figure 1). The response rate of cancer patients or their relatives was 26%. Figure 1 presents the details of the data flow from the three data sources, and the Venn diagram (Figure 2) shows the share of data from each data sources. Finally a linkage of the data from the three data sources provided 2232 cases of cancer death for statistical analysis (Table 2). The majority of the patients were men (62.1%), and most of them were 50 years or older (58.6%). In addition, 904 (40.50) cases were from Shiraz City and 1324 (59.32%) were from other cities (Table 2). We present the results of eight models that estimated the true number of cancer deaths from the three data sources in Fars Province in Table 3. Based on the 4th model, which was assumed to be the optimal model in this data that showed the lowest AIC (8.5) and BIC (-2.62) measurements, we estimated that 3309 cancer deaths have occurred in Fars Province between 2004 and 2006 (95% CI 3151 – 3293) (Table 3). This finding indicates 58% coverage and 42% underestimation of the cancer death in the Fars province death registry (Table 4). ASMR for all cancer types increased from 44.8 per 100,000 (95% CI 42.8 – 46.7) which was reported by mortality registry to 76.3 per 100,000 (95% CI 73.3 – 78.9) which was estimated in this study. Based on the corrected estimation, the highest mortality rates were observed for lung (ASMR 25 per 100,000) and stomach (ASMR 23.5 per 100,000) cancers and the lowest rates were observed for colon (3.0 per 100,000) and esophageal (2.7 per 100,000) cancers.

Table 3. Observed and estimated numbers of cancer deaths between 2004 and 2006 in Fars province, using three-source captures recapture method.

	Observed No. of death	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Source 1	1528	1452	1455	1455	1528	1483	1528	1528	1528
Source 2	137	159	137	170	144	137	137	140	137
Source 3	98	112	129	98	93	98	97	98	98
Source 1&2	212	266	285	252	205	257	212	209	212
Source 1&3	126	188	168	199	131	171	127	126	126
Source 2&3	56	21	25	23	54	56	57	53	56
Source 1, 2&3	75	35	33	35	77	30	74	78	75
None of the sources	0	864	700	716	1077	240	987	1188	1029
Total estimated number(95% CI)	2232	3096 (2975–3236)	2932 (2802–089)	2948 (2797–3139)	3309 (3151–3293)	2472 (2397–2579)	3219 (3023–3463)	3420 (3140–3786)	3261 (2863–3908)
AIC		25.29	24.15	24.96	8.5	18.79	8.61	8.67	8.89
BIC		115.00	106.93	112.63	-2.62	69.38	-1.91	-1.46	4.17 e $^{-14}$

Model 1: $\mu_{ijk} = \lambda + \lambda_i^{s1} + \lambda_j^{s2} + \lambda_k^{s3}$: all the source independently in model

Model 2: $\mu_{ijk} = \lambda + \lambda_i^{s1} + \lambda_j^{s2} + \lambda_k^{s3} + \lambda_{ik}^{s1s3}$: all the source independently in model and interaction of s1 and s3

Model 3: $\mu_{ijk} = \lambda + \lambda_i^{s1} + \lambda_j^{s2} + \lambda_k^{s3} + \lambda_{ij}^{s1s2}$:all the source independently in model and interaction of s1 and s2

Model 4: $\mu_{ijk} = \lambda + \lambda_i^{s1} + \lambda_j^{s2} + \lambda_k^{s3} + \lambda_{ij}^{s3s2}$:all the source independently in model and interaction of s3 and s2

Model 5: $\mu_{ijk} = \lambda + \lambda_i^{s1} + \lambda_j^{s2} + \lambda_k^{s3} + \lambda_{ij}^{s1s2} + \lambda_{ik}^{s1s3}$:all the source independently in model and interaction of s1 & s2 and s1&s3

Model 6: $\mu_{ijk} = \lambda + \lambda_i^{s1} + \lambda_j^{s2} + \lambda_k^{s3} + \lambda_{ij}^{s3s2} + \lambda_{ik}^{s1s3}$:all the source independently in model and interaction of s3 & s2 and s1&s3

Model 7: $\mu_{ijk} = \lambda + \lambda_i^{s1} + \lambda_j^{s2} + \lambda_k^{s3} + \lambda_{ij}^{s3s2} + \lambda_{ik}^{s1s2}$:all the source independently in model and interaction of s3 &s2 and s1&s2

Model 8: $\mu_{ijk} = \lambda + \lambda_i^{s1} + \lambda_j^{s2} + \lambda_k^{s3} + \lambda_{ij}^{s3s2} + \lambda_{ik}^{s1s2} + \lambda_{ik}^{s1s3}$:all the source independently in model and interaction of s3 &s2 and s1&s2

Table 4. Observed and estimated mortality rates of cancer in overall and for common cancers in Fars provinces in the southern part of Iran in 2004–2006.

Cancer	Observed			Estimated			Underreporting rate %
	N. of death	MR/100,000	ASMR/100,000	N. of death	MR/100,000	ASMR/100,000	
All Cancer	1941	44.7	44.8 (42.8–46.7)	3309	76.2	76.3 (73.3–78.9)	42
Male	1224	55.51	55.5 (52.4–58.6)	1651	74.8	74.9 (71.3–78.5)	
Female	716	33.58	33.6 (31.1–36)	1718	80.5	80.6 (76.8–84.4)	
Bladder Cancer	90	2.007	2.1 (1.6–2.5)	226	5.2	5.2 (4.5–5.9)	60
Male	77	3.49	3.5 (2.7–4.3)	211	9.5	9.6 (8.3–10.9)	
Female	13	0.60	0.60 (0.30– 0.90)	23	1.07	1.1 (0.6–1.5)	
Colon Cancer	85	1.95	2.0 (1.5–2.4)	130	2.9	3.0 (2.5–3.5)	35
Male	57	2.58	2.6 (1.9–3.3)	90	4.08	4.1 (3.2–4.9)	
Female	28	1.31	1.3 (0.8–1.8)	41	1.9	1.9 (1.3–2.5)	
Rectal Cancer	20	0.46	0.5 (0.3–0.7)	30	6.9	6.9 (0.61–0.77)	33
Male	9	0.40	0.4 (0.1–0.7)	11	0.86	0.9 (0.5–0.12)	
Female	11	0.51	0.5 (0.2–0.8)	19	0.89	0.9 (0.5–0.13)	
Esophageal Cancer	66	1.56	1.5 (1.2–1.9)	118	3.7	2.7 (2.2–3.2)	44
Male	41	1.85	1.9 (1.3–2.4)	67	3.03	3.0 (2.3–3.8)	
Female	25	1.17	1.2 (0.7–1.6)	125	5.8	5.9 (4.8–6.9)	
Lung Cancer	555	12.79	12.8 (11.7–13.9)	1085	25.01	25 (23.5–26.5)	48
Male	393	17.82	17.8 (16.1–19.6)	692	31.3	31.4 (29–33.7)	
Female	161	7.55	7.6 (6.4–8.7)	530	24.8	24.9 (22.7–27)	
Stomach Cancer	708	16.32	16.3 (15.1–17.5)	1020	23.5	23.5 (22.1–25)	30
Male	453	20.54	20.5 (18.7–22.4)	1067	48.3	48.4 (45.5–51.3)	
Female	255	11.9	12.0 (10.5–17.5)	346	16.2	16.2 (14.5–17.9)	
Ovarian Cancer**	16	0.75	0.8 (0.4–0.11)	28	1.31	1.3 (0.8–1.8)	42
Breast Cancer**	165	7.73	7.7 (6.6–8.9)	227	10.6	10.6 (9.3–12.0)	27
Endometrial Cancer**	59	2.76	2.8 (2.1–3.5)	120	5.6	5.6 (4.6 –6.6)	50
Prostate Cancer**	211	9.56	9.6 (8.3–10.9)	311	14.1	14.1 (12.5–15.7)	32

*MR: Crude Mortality Rate; ASMR: Age Standardized Mortality Rate; ** Breast cancer was restricted to women

Discussion

We used the capture–recapture method and discovered that the current death registry underestimates the true mortality rate of cancer by about 40% in Fars Province, I. R. of Iran. After correction of the underestimation rate, cancer mortality rate increased from 44.8 per 100,000 to 76.3 per 100,000.

We used the log-linear method for statistical analyses, in which the data sources should not subset from one another and at least three data sources are available for analyses.[25] Although the three data sources were collected independently, the pathology-based cancer registry was thought to be a subset of the hospital records and these two data sources may not be assumed as two independent databases. However, this is not true for many of the cancers in the developing countries, where some of the patients are diagnosed at an advanced stage and are not operated upon or sent for histo-pathological diagnosis. Therefore, the three data sources could be seen as independent data sources that have their own specific data, which is not shared by the other sources.

We followed cancer patients who were diagnosed between 2001 and 2006 and selected the deaths that occurred between 2004 and 2006. This has led to a limited estimation of cancer deaths in the generated data sources, therefore provided limited power for the appropriate estimations in our model. It may then, cause some instability in the estimated figures provided by our statistical model. For example, the numbers of deaths resulting from lung and stomach cancers that are diagnosed at a very advanced stage and have a poor prognosis were proportionally higher in the death registries compared with the pathology and hospital sources. However, our estimates for the combined cancer types stem from a reasonable power and should be close to the actual numbers. According to the Globocan 2008, for all cancers, the age standardized mortality rate was 80.5 per 100,000 which is close to the estimation provided from this (76.3 per 100,000).[26]

Lung cancer is usually diagnosed in the advanced stages and is a common cause of cancer death worldwide. It is generally diagnosed clinically and is not accounted for by the pathology registries. In an audit of cancer registries in Iran, lung cancer had the highest underestimated rate (approximately 80%) in the pathology-based cancer registry.[4] Our results supported these findings and we found a high underestimation for lung cancer, although lung cancer was not the most common cancer among the Iranian population.[27] Based on our results, the true incidence and mortality rate seems to be much higher than that reported by the pathology-based cancer registry and national death registry.[28]

We found a small number of deaths caused by rectal cancer in the death registry, which could be because of the misclassification of rectal and colon cancer in the death certificates. Many patients and their next-of-kin are unaware of the exact diagnosis of cancer and rectal or colon cancer may be easily misclassified when the physician issues the certificate. Although the sensitivity of rectal cancer was 5% in the death registry, when we combined the colon and rectal cancers and analyzed them together as colorectal cancer, the sensitivity reached 66%. The sensitivity of the death registry was also low for colorectal cancer in the Virginia death registry; it was reported to be approximately 60% for colorectal cancer.[32]

Overall, the sensitivity of our system in the diagnosis of all cancer mortality was very low (58%); it was considerably lower than the rate reported in the Netherlands (98.3%),[20] and Germany (95.5%).[33] When we estimated the true number of deaths caused by cancer, the number of cancers increased from 1941 to 3309, indicating that the true cancer mortality is much higher than the rate reported by the mortality registry. An analysis of data from a cohort study in Korea showed that the sensitivity of the death registry was high.[34] The overall sensitivity of cancer registries in Gambia was 50.3%,[35] whereas the overall under-registration of deaths was 9% in Thailand.[6] However, the completeness of death registration in Brazil varies from 72% to 80% in the northeast regions, compared with 85% to 90% in the Southeast and Center-West regions, and 94% to 97% in the wealthier Southern region.[5]

Many developing countries lack well-functioning cancer and death registration systems.[36] According to the World Health Organization, approximately 80% of NCD deaths (29 million) occur in low- and middle-income countries.[37] Developing countries need to improve the management of their death registration systems and provide valid statistics for causes of death and important tools for the monitoring of public health interventions.

Although the capture- recapture method has been widely used for estimation of different disease rates, to the best of our knowledge, this method has not been previously used for estimation of cancer death. In addition to the data from mortality registry, we created two data sources for cancer death through active follow-up of the cancer patients and applied capture recapture analyses for estimation of true cancer mortality rate and evaluation of the quality of mortality registry vis-à-vis cancer death. In spite of the strength of this study, it faces a few limitations. Because there was no unique identification number, we used probabilistic approach for data linkage. We used six variables including patient name, family name, father's name, age, date of birth, and place of residence for data linkage and removed the duplicates. The Persian names may be spelled slightly differently in the sources we used for data linkage. We manually fixed the errors and differences. However, in a few cases (less than 5%), we failed to identify the information and detect the duplicates. Because of our rigorous approach, the impact of this limitation on the results of this study should be minimal.

In conclusion, we observed considerable underestimation in the cancer mortality rate among the Iranian death registry. Efforts to improve the validity of information and coverage of the death registry for cancer mortality are necessary. A regular audit in addition to monitoring and evaluation activities should be an essential part of the death registration system to ensure validity and completeness of death as well as accuracy of case-specific mortality rates. In addition, an update of the guidelines for issuing the death certificates, as well as training of medical doctors and other health professionals who are involved in issuing the death certificate may improve the standard of the death registry in I. R. of Iran.

Conflicts of Interest and Acknowledgment

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Unfortunately one of our co-authors, Dr. Eshagh Dortaj, who contributed completely in this research died before this manuscript could be published. We would like to honor his memory.

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