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Estimation of Oncologists' Active Supply in Iran: Three Sources Capture-Recapture Method

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Abstract

Background: Cancer is the third cause of death in Iran. Oncologists play a key role in declining the mortality rate of cancer.
Objectives: This study aims to accurately estimate oncologists' active supply by using 3 sources of capture-recapture (CRC) in Iran.
Methods: This was a cross-sectional study in 2015 targeting all oncologists in Iran registered in 3 independent sources, a hospitals national survey (213), database of Iran ministry of health and medical education (180), and the database of continuing medical education (173) were used to identify number of oncologists that were active. Duplicate records between the 3 sources were identified and removed using the Microsoft Office Access software. Medical council codes, names, surnames, as well as national ID codes were used for data linkage between the 3 sources.
Results: After removing the duplicate records, a total of 314 oncologists were identified. Based on the selected model, it was estimated that the total number of oncologists were 533 in 2015. They included 325 adult hematologist-oncologists, followed by 88 pediatric oncologists, 47 surgical oncologists, 20 gynecologic oncologists, and 18 urologic oncologists. The estimated ratios for oncologist to population and oncologist to patients suffering from cancer were 0.67 and 1.34 per 100,000, respectively. Completeness of data for all 3 data sources after removing duplicates was 59.13%.
Conclusions: This study highlighted the shortage of oncologists in Iran and showed that the quality of Iran specialists' registration databases needs improvement.

Keywords: Oncologist, Capture-Recapture, Supply, Iran

1. Background

Cancer is an important cause of death and a major drain on healthcare resources worldwide (1). Iran, as a developing country, is currently undergoing an epidemiological transition from communicable to non-communicable diseases (2, 3). Recent studies show that cancer is the third cause of death in Iran (4). According to American society of clinical oncology, there is an urgent need for a multidisciplinary approach to encounter this challenge (5). Oncologists are among the health professionals that are directly involved in the care and management of cancers including prevention, early detection, diagnosis, treatment, survival, palliative care, and research (1). It is therefore, important that enough oncologists are available and active in any country. There is however, inaccurate data regarding the number of specialists including oncologists in Iran (6). In fact, gathering and updating specialists' data encounters different obstacles due to numerous limitations (7).

The main data source that is normally used to estimate the number of physicians is national medical council masterfile (7, 8). However, retrieved data from this source is suspicious of physicians' over-estimation or under-estimations. As one study indicates 6% over-estimation is due to the delay in data updating at the time of retirement, death, or change in one's change of specialty, location, immigration etc. However, it is not the only pitfall; for instance, there could be under-estimation due to missing data entries (7). In a US study, the baseline capacity of oncologists is determined by analyzing physicians' supply data gathered from surveys of practicing oncologists, oncology fellows, and fellowship program di-

rectors, along with American medical association (AMA) masterfile data on practicing medical oncologists, hematologists/oncologists, and gynecologic oncologists (9). In Iran, physicians' medical council codes lack continuous updates in terms of decease, change and/or attainment of specialty, and shift of professional areas. Therefore, using medical council data might result in over-estimation or under-estimation of active physicians supply, especially in specialty areas. In addition to existing data banks, some studies have conducted surveys to determine the current and projected supply, demand and shortfall of medical oncologists (10). Other studies have synchronized medical council masterfiles with telephone directories to estimate the number of active physicians (6, 11). It is however, argued that none of the above mentioned is reliable due to possible over or under estimation. There are however, statistical methods such as capture-recapture technique that is used to minimize the bias in accurate estimation of physicians. CRC method was first used to estimate animal population (12) and then it evolved to other epidemiologic subjects to estimate diseases prevalence or any situation that available data sources are not complete. To use this method, some assumptions should be considered e.g. the sources are independent and all individuals inside the same source have an equal opportunity to be included (12, 13). Previous studies in Iran used CRC to estimate prevalence of subjects such as road traffic injuries (14), esophagus cancer (15), lung cancer (16) gastric cancer (17) and many more. As stated before, other studies used adjusting methods for medical council data banks. The current study used the capture-recapture (CRC) method since it has been used in epidemiologic studies as one of the best methods for estimations when different data banks exist. Moreover, it is the first time that this method is applied for estimation of specialists. This study aims to estimate oncologists' active supply using 3 sources of CRC in Iran.

2. Methods

2.1. Data Gathering

This study was a cross-sectional study in 2015 targeting all oncologists in Iran and it used data from 3 independent sources; a hospitals national survey, database of Iran ministry of health, and medical education, and database of continuing medical education (CME) to identify the number of oncologists who were active. The hospital survey was conducted in all 925 Iranian hospitals in 2015 using each hospital's personnel records including hospitals that were affiliated to MOHME, social insurance organization (SIO), military service, private, charity, and other public organization hospitals. The rest of the data was obtained from the nationally registered database of human resources management (HRM) office in MOHME that has a list of specialists employed by the health ministry. This source is regularly updated according to the physicians' activity in the ministry service delivery locations. The third nationally registered data source includes specialists who participated in the CME courses. These courses are held annually with the aim of increasing the level of scientific and technical knowledge of physicians in addition to their professional skills. Specialists need to participate in these courses in order to renew their office licenses; therefore, it is highly likely that the participants are the active workforce in the country. Data from these data sets represented the official number of active oncologists. To retrieve the total number of active oncologists from the survey as the first set, we used 3 phases as follows respectively; data gathering, quality assessment, and completion of missed data. In the first phase, an Excel form was developed along with an instruction. They were then sent to the provinces medical universities through an official letter from MOHME. The form requested data on specialists (including oncologists), their demographic characteristics, national identification code, medical council code, field of specialty, hospital name, province, town, and the type of organization authority. In phase 2, based on the instruction, we assessed the accuracy of data fields in the received forms. During the last phase, we completed the blank fields by matching with the medical council master file in Microsoft Office Access software version 2007. The medical universities assigned focal points for their data gathering. The research team contacted them frequently to follow up on the work progress and to finalize the data; each focal point was contacted with 1, 2 and 3 months of intervals after receipt of the forms. For those who did not respond or partially completed, we used 2 reminding methods of official letters and phoning the focal points.

Information regarding cancer prevalence was extracted from the Iranian annual of national cancer registration report (18). Population information was obtained from Iran's statistics center (19).

2.2. Data Linkage

The duplicate records between MOHME, CME, and the hospital survey were identified and removed using Microsoft Office Access software version 2007. The primary data linkage was performed by corresponding the national ID codes with the individuals' medical council codes. If it was not successful, the data were matched through both name and last name with the oncology field or name and last name with their city.

2.3. Statistical Analysis

After identifying the common subjects between the 3 sources using data linkage, the total number of oncologists in Iran was estimated by the 3-source capture-recapture method using log-linear models. Before using the capture-recapture method, we considered some assumptions such as independency of sources (our 3 sources of information assumed to be independent of each other) and it was assumed that all oncologists who were in each data had an equal chance to be included in this study (12, 13).

Three source capture-recapture and log-linear model was used to estimate a more accurate number of oncologists, completeness of every data source registries, oncologists to population ratio, and oncologists to people suffering from cancer ratio in Iran. Additionally, we considered the interactions between the 3 sources in log linear model. Considering the 3 sources of registries in this study, we had eight possible combinations of these registers in which people do or do not appear in data sources. To evaluate the model's fitting we used the G^2 test, also known as log likelihood-ratio, Akaike's information criterion (AIC), and Bayesian information criteria (BIC), then the best model among possible various log-linear models was selected. The model with a lower amount of AIC was chosen as the best model and STATA software, version 12 (StataCorp, Texas, USA) was used for all computations.

3. Results

3.1. Data Gathering

Out of 925 hospitals in Iran, 838 hospitals (91%) completed the survey. 45 of them (4.86%) declined to participate and 42 hospitals (4.5%) did not respond. After removing duplicate records between the 3 sources, a total of 314 oncologists were identified. The hospital survey (A), MOHME HR data source (B) and CME data source (C) reported 213, 180, and 174 oncologists, respectively. 229 (72.90%) oncologists of total 314 were male. The mean age of the oncologists was 49.14 ($\pm$ 9.49) years for men and 49.39 ($\pm$ 8.31) years for women. A Venn diagram below shows the detailes of common oncologists between the hospital survey, MOHME, and CME data sources (Figure 1).

3.2. Current Supply

Characteristics of the reported oncologists in the 3 mentioned sources are shown in Table 1. The oncologists in all data sources worked in public hospitals. Based on our findings in data source A, B, and C, 150 (70%), 165 (92%), and 128 (74%) of the subjects worked in the academic settings, respectively and also about 75% of oncologists in each data source were male. Within the oncologist field, we found that the majority of oncologists (58% - 74%) were adult hematologists/oncologists. Furthermore, results revealed that the majority of oncologists were between the ages of 45 to 55.

Table 1. Charasteistics of Oncologicts Based on Three Independent Sources in 2015

	Hospital Survey (A)	MOHME (B)	CME (C)
Work Place			
Public hospitals	187 (88)	169 (94)	147 (84)
Private hospitals/clinics	21 (10)	0	15 (9)
Research centers	5 (2)	11 (6)	12 (7)
Academic Situation			
Academic	150 (70)	165 (92)	128 (74)
Non-academic	63 (30)	15 (8)	46 (26)
Sex			
Male	162 (76)	137 (76)	130 (75)
Female	51 (24)	43 (24)	44 (25)
Field			
Pediatric oncologist	40 (19)	41 (23)	44 (25)
Adult hematologist-oncologist	133 (62)	133 (74)	101 (58)
Cancer Surgery	18 ()	4 (2)	14 (8)
Urologic oncologist	12 ()	0	6 (3)
Gynecologic oncologist	10 (5)	2 (1)	9 (5)
Age			
30 >	1 (0)	0	0
30 - 35	2 (1)	0	0
35 - 40	15 (7)	14 (8)	10 (6)
40 - 45	46 (22)	50 (28)	33 (19)
45 - 50	59 (28)	47 (26)	51 (29)
50 - 55	50 (23)	44 (24)	46 (26)
55 - 60	17 (8)	22 (12)	14 (8)
60 - 65	6 (3)	0	5 (3)
65 - 70	7 (3)	0	6 (3)
70 - 75	5 (2)	2 (1)	3 (2)
75 - 80	1 (0)	1 (1)	2 (1)
80 <	4 (2)	0	4 (2)

As Figure 1 shows, the capital of Iran has a higher ratio of oncologists in relation to their population comparing to the other provinces. For instance, there are 0.83 oncolo-

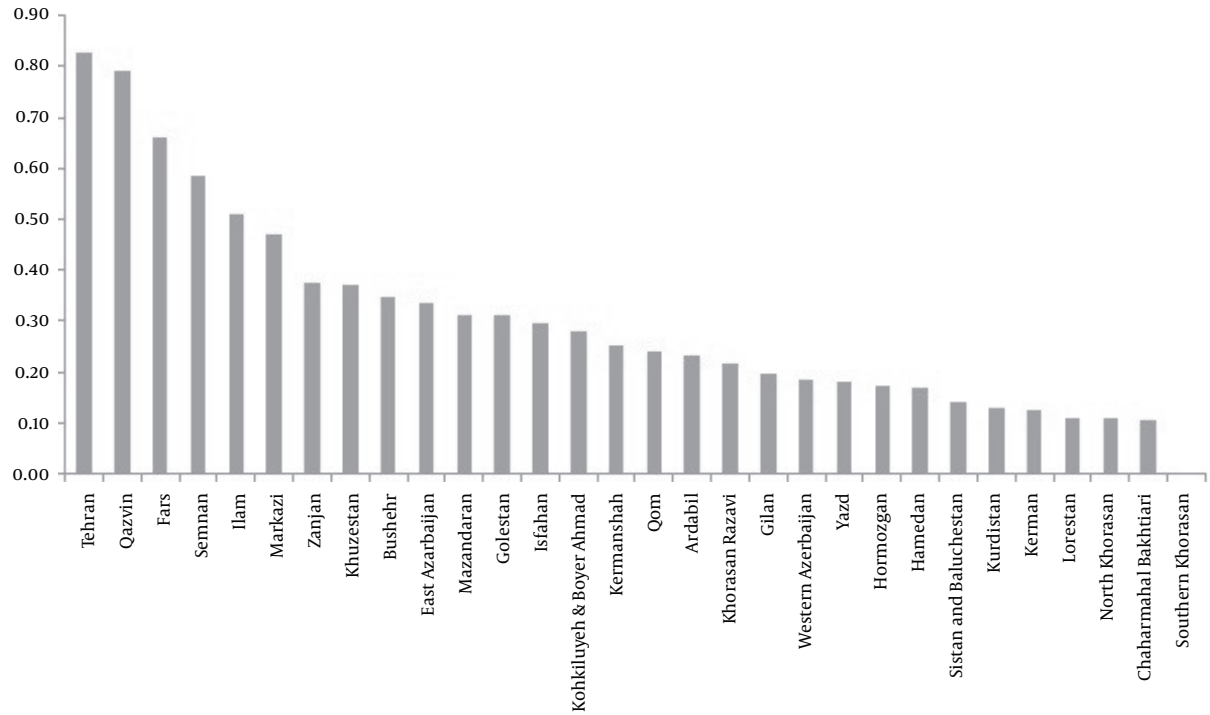

Figure 1. Provincial Distribution of Oncologicts to Populalation Ratio (10,000), Based on Three Independent Sources, After Removing Duplicates in 2015

gists per 100.000 populations in Tehran while the ratio in other cities is 0.59 - 0.8.

3.3. Estimated Supply Using Capture-Recapture

In the 3 source capture-recapture analysis with log-linear model, a model was selected for the sources 2 by 2 independently (C & A, C & B, A & B). This model has a good fitting according to lowest value of Akaike's information criterion (AIC) and Bayesian information criterion (BIC), 60.01 and 59.69, respectively (Table 2). The estimated total number of oncologist in 2015 was 533.82 (95% CI: 431.62 - 724.81) and there was an estimate of 219.82 oncologists who were not included in any of the 3 data sources (Tables 2 and 3). The completeness of registration for all 3 data sources was 59.13% (314 subjects) after removing duplicates and for hospital survey (A), MOHME HR (B) and CME (C) were 39.96% (213 records), 33.77% (180 records), and 32.64% (174 records), respectively (Table 3).

The estimated number of oncologists using the log-linear model was 384.19 (95%CI: 304.05 - 549.91) and 145.16 (95%CI: 103.48 - 280.84) in male and female subgroups, respectively. Furthermore, the estimated number of oncologists by field of specialty subgroup was 325.9 (95%CI: 260.16 - 462.26), 47.50 (95%CI: 21.17 - 661.31), 20.50 (95%CI: 13.24 - 245.11), 88.64 (95%CI: 74.20 - 152.61), and 18.50 (95%CI: 12.11 - 365.00) for adult hematologist-oncologist, surgical oncologist, gynecologic oncologist, pediatric oncologist, and urologic oncologist, respectively. The majority of estimated oncologists were male 384.19 (72.5%) and 381.3 (73.02%) aged between 41 to 60. More than half of the total number of oncologists were adult hematologist-oncologist 325.9 (65%) and urologic oncologist 18.5 (3.7%) (Table 3).

Table 4 illustrates the dimensions of the oncologists avaliabilty based on 2 main measures. There is 0.67 oncologist per 100,000 population and 1.34 oncologist per 100,000 patients suffering from cancer. The avaialibility of adult hematologist-oncologist was higher than other fields of specialty (0.41 in measure 1 and 0.82 in measure 2).

4. Discussion

This study was initiated with the notion to reach a more accurate estimation of the current number of active oncologists by field in Iran. Using the CRC method to count, findings show that the estimated number of oncologists in Iran has increased substantially when compared to existing data sources. According to the data sets, the numbers were 213, 180, and 174 while this study attained

Table 2. Model Selection in Log-Linear Analysis by AIC, BIC and G^2 Statistics[a]

Model	X[b]	N[c]	95% CI for N	DF[d]	G^{2e}	BIC[e]	AIC[e]
C/A/B	32.32	346.32	(337.92 - 357.67)	4	187.09	247.25	247.47
CA/B	128.25	442.25	(405.66 - 493.45)	5	14.88	62.18	62.45
CB/A	22.35	336.35	(329 - 347.31)	5	170.1	239.51	239.78
AB/C	11.91	325.91	(320.67 - 335.25)	5	144.31	222.62	222.89
CA/CB	219.82	533.82	(431.62 - 724.81)	6	10.35	59.69	60.01
CA/AB	2389	2703.49	(454.95 - 40821.36)	6	6.22	52.85	53.18
CB/AB	6.22	320.22	(317.23 - 325.99)	6	127.22	205.03	205.35
CA/CB/AB	5508.72	5822.72	(614.800 - 101198.10)	7	0	48.38	48.76

[a] C, continuing medical education source. A, hospitals survey Source. B, MOHME HR bank; Model C/A/B, A model where all available resources are independent; Model CA/B, A model where sources C and A are dependent and independent of the source B; Model CB/A, A model where sources C and B are dependent and independent of the source A; Model AB/C, A model where sources A and B are dependent and independent of the source C; Model CA/CB, A model where two sources C and A and also two sources C and B are mutually interdependent and two sources A and B are independent; Model CA/AB, A model where two sources C and A and also two sources A and B are mutually interdependent and two sources C and B are independent; Model CB/AB, A model where two sources C and B and also two sources A and B are mutually interdependent and two sources C and A are independent; Model CA/CB/AB: A model where all two-way interaction between resources are exist
[b] The estimated number of oncologists that were not recorded in any of three sources.
[c] The estimated total number of oncologists in Iran in 2015.
[d] Degree of freedom.
[e] Akaike's Information Criterion/Bayesian Information Criterion/Goodness of fit.

Table 3. Estimated Number of Oncologists by Log-Linear Model Based on Three Independent Sources in 2015

Subgroups		Reported Number of Oncologist[a]	Estimated Number of Oncologist	95% CI for Estimated Number of Oncologist	Completeness of Registration,[b] %
Gender	Male	229	384.19	(304.05 - 549.91)	59.60
	Female	85	145.16	(103.48 - 280.84)	58.55
Age groups	40 ≥	41	80.35	(51.41 - 189.70)	51.01
	41 - 60	245	381.3	(311.09 - 526.06)	64.25
	60 <	28	60.5	(29.41 - 773.06)	46.28
Field of Specialty	Adult hematologist-oncologist	199	325.9	(260.16 - 462.26)	61.06
	Surgical oncologist	20	47.5	(21.17 - 661.31)	42.10
	Gynecologic oncologist	13	20.5	(13.24 - 245.11)	63.41
	Pediatric oncologist	70	88.64	(74.20 - 152.61)	78.98
	Urologic oncologist	12	18.5	(12.11 - 365.00)	64.86
Total		314	533.82	(431.62 - 724.81)	58.82

[a] Number of reported oncologists by MOHME HR bank, hospitals survey and CME after removing duplicates.
[b] Number of reported records divided by the estimated number.

534. This higher figure is not surprising since specialty fields were not updated due to deficiency in registration process and the fact that all of the oncologists were in subspecialty or fellowship level. Moreover, since the response rate of the survey was 91%, the remaining 10% probably represents some missed records of current oncologists. Therefore, considering the previously mentioned limitation of the current data, it seems that the results of this method are closer to the reality. However, the main limitation of this study is that the overlaps from the 3 sources are small and the result attained may have an slight overestimation (20).

Based on the frequencies of oncologists in the 3 data sources, total announced data related to Tehran counts as 30% on average, this is while 3% of cancer prevalence is from Tehran (18). Despite the fact that 53% of total cancer prevalence in Iran relates to just 5 provinces other than Tehran, total announced data related to these provinces

Table 4. Estimated Oncologists to Population Ratio and Oncologists to People Suffering from Cancer Ratio in 2015

Subgroups	Oncologists to Population (100,000)	Oncologists to People Suffering from Cancer (1000)
Adult hematologist-oncologist	0.41	4.48
Surgical oncologist	0.06	0.6
Gynecologic oncologist	0.03	0.28
pediatric oncologist	0.11	1.2
Urologic oncologist	0.02	0.25
Total	0.67	7.34

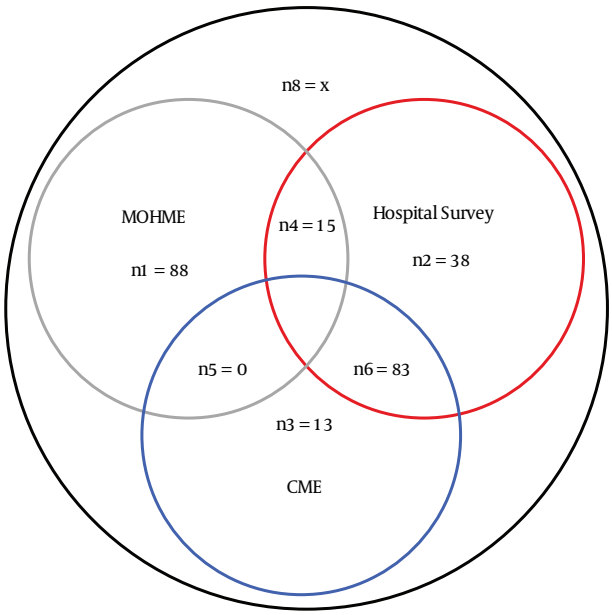

Figure 2. Venn Diagram for the Common Records of Oncologists Between A (Hospital-Survey), B (MOHME) and C (Continues Medical Education)

was 31% on average (21). Other studies indicate that metropolises with more beds tend to attract more physicians (18), as approximately 39.6% of physicians and 20.6% of patient beds are concentrated in Bangkok metropolis (22). Likewise, since Tehran is the capital with bigger health facilities than other provinces (23) having about 21.3% share of total cancer facilities, it is probably the reason to attract more oncologists (10). Although, there is no consensus on the ideal geographic concentration of physicians, the distribution of oncologists should meet the population's needs and provide sufficient accessibility to health care services (18). In our case, we primarily determined the adequacy of oncologists supply. As it is mentioned in results, Iran's national ratio of oncologists per 100,000 population was 0.67 with a population of 79,686,000 in 2015, while this ratio in US is in a range of 1.5 - 2.6 (24). More specifically, our findings indicate that total number of adult hematologist-oncologist per 100,000 population was 0.4 and this ratio is 0.93 in Turkey (25). In spite of the fact that the estimated figure was higher than the reported ones, there has been a significant difference between our oncologist ratio and the other countries (per 100,000 population).

Iran is experiencing an increasing growth in cancer incidences together with the population aging (4), therefore, due to the age-sensitive nature of cancer, it is expected that demand for oncology services harshly increase throughout the next 10 years (9, 10). However, comparison with each of the mentioned ratio shows shortage of oncologists to meet current and future demand for oncology services. It is likely that the shortage exacerbates if the estimation method, which was based on a headcount of oncologists changes to the full-time equivalent (FTE) method.

Comparison of studies regarding calculation of FTE for the oncologists can create a paradox. Some studies indicate that supply is sufficient on the whole while other studies demonstrate shortage. On the other hand, a study indicated that male hematologists-oncologists performed 17% more visits comparing to females (26). Likewise, results of the present study shows that 72.5% of the oncologists are male and more than half of total oncologists are hematologist-oncologists. On the other hand, a study shows that oncologists who have an academic position (32%) allocate little time to clinical services (20). Consistently, the present study found that on average about 31% of the oncologists have been working in academic settings. Therefore, to better comprehend this paradox it is essential to conduct a precise research into oncologists supply based on FTE calculation.

The completeness of active physicians registry in U.S master file was 90% (7) and it is much more than results of our study (59.13%). Thus, the results of our study confirmed that the quality of specialists' registration in Iran is imprecise and needs to enhance its quality. Some strategies could be used such as linking databases of all responsible organizations through a unique code such as national ID code or medical council code to register specialists' information e.g. their activity status, field and specialty certificate/ Diploma, immigration, retirement, and more. One of the limitations of this study is the lack of similar studies for workforce estimations using 3 sources of CRC method to estimate current active workforce (it is oncologists in the present study). It is noted that the CRC method is still known to be the best and rapidest method to estimate active oncologists managing the mentioned registration

problems of specialists, especially regarding outflows such as immigration. Additionally, the strength of this study is the selection of data banks, which had records of active oncologists; indeed, they are an appropriate reference population for active oncologists. Knowledge gained from this study indicates that the number of oncologists in Iran has been underestimated and this fact enables the MOHME policy makers to plan health policies more accurately to address the oncologist's requirement.

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Footnote

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