RESEARCH ARTICLE

Application of a Network Scale-up Method to Estimate the Size of Population of Breast, Ovarian/Cervical, Prostate and Bladder Cancers

Ali Akbar Haghdoost[1], Mohammad Reza Baneshi[2], Saeedeh Haji-Maghsoodi[3], Hossein Molavi-Vardanjani[4], Elham Mohebbi[2]*

Abstract

Network scale up (NSU) is a novel approach to estimate parameters in hard to reach populations through asking people the number of individuals they know in their active social network. Although the method have been used in hidden populations, advantages of NSU indicate that exploration of applicability to disease like cancer might be feasible. The aim of this study was to assess the application of NSU to estimate the size of the population of breast, ovarian/cervical, prostate, and bladder cancers in the South-east of Iran. A total of 3,052 (99% response rate) Kermanian people were interviewed in 2012-2013. Based on NSU, participants were asked about if they know any people on their social network who suffered from breast, ovarian/cervical, prostate, and bladder cancers, if yes, they should enumerate them. A total of 1,650 persons living with four types of cancers (breast, ovary/cervix, prostate, and bladder) were identified by the respondents. Totally, the prevalence of people living with the four types of cancers was 228.4 per 100,000 Kermanian inhabitants. The most prevalent cancer was breast cancer, at 168.9 per 100,000, followed by prostate cancer with 116.9, ovarian/cervical cancer with 99.8, and bladder cancer with 36.3 per 100000 Kerman city population. NSU values provide a usable but not very precise way of estimating the size of subpopulations in the context of the four major cancers (breast, ovary/cervix, prostate, and bladder).

Keywords: Neoplasm - social network - breast - ovary - cervix - bladder - prostate

Introduction

Cancer is a major public health challenge in the world. More than 14 million new cancer cases and about 8 million cancer deaths have been reported annually, whereas the majority of incidence and death belongs to less developed countries (Ferlay et al., 2013). It is expected that annual cancer cases will rise from 14 million in 2012 to 22 within the next two decades (Mousavi et al., 2007). This enhancing of the new cases of cancers compels governments demanding accurate data to plan and allocate appropriate resources.

Incidence of cancer increasing in developing countries as a result of population aging and lifestyle such as smoking, physical inactivity, obesity, and stress. It is expected to increase the number of new cases of cancer from 10 million per year in 2000 to 15 in 2020, and nearly 60% of them occurred in developing countries (Parkin et al., 1999).

Iran is a developing country experiencing dramatic increase in population growth especially after 1979

revolution while the life style of the population become progressively worse which leads 98-100 per 100,000 new cases of cancer in Iran (Mousavi et al., 2009; Keyghobadi et al., 2015; Veisy et al., 2015). Although all type of cancers are noteworthy for health systems, some type of cancers like breast, Ovary, cervix, prostate, and bladder are socially and economically dominant. The incidence of such cancers have been elevating, hence, looking for optimal, feasible, and effective solutions is indispensable.

Knowing the incidence, prevalence and mortality of cancer is the initial tool helping stakeholders in programming and implementing appropriate policies to control effectively and allocate proper resources. In Iran, cancer registries are the only source of presenting such data but the quality, validity, comparability, completeness, and timeliness of the data are not very trustworthy (Sadjadi et al., 2008). Hence, new methods should be designed or explored to increase the quality of the data and also the capability of the methods to detect low prevalent events like some of cancers.

Many size estimation methods have been tested and

[1]Regional Knowledge Hub, and WHO Collaborating Centre for HIV Surveillance, [2]Research Center for Modeling in Health, [3]Research Center for Social Determinants of Health, [4]Research Center for Health Services Management, Institute for Futures Studies in Health, Kerman University of Medical Sciences, Kerman, Iran *For correspondence: mohebi.el@gmailcom

applied to achieve the most valid measures. Besides, cost effectiveness and easy to run are also very substantial, especially for developing countries. Size estimation methods are various but totally they are categorized to direct and indirect methods. It has been determined that direct methods such as survey and census are very costly and also prone to different type of biases, furthermore, demanding more sample size is the most serious drawback of the direct methods (Rastegari et al., 2013). On the other hand, meeting assumptions behind indirect methods like capture-recapture and multiplier is sometimes very difficult. An almost novel indirect method is network scale up (NSU) which has been almost used in hard to reach populations but the point about NSU like more applicability, easiness, and cost-effectiveness to estimate the size of many sub-populations than other indirect methods differentiate it from the other methods (Jackson et al., 2005; Bernard et al., 2010). Because of the basic assumption of the method, active social network, every individual transfer information behalf of their network, therefore less samples are needed to evaluate(Jackson et al., 2005). Consequently, reported number of people known (m) in a subpopulation of the general population (T) could calculated proportion of subpopulation (e) [$m/C=e/T$]; when: 1) individuals have an equal chance to the subpopulation of interest, 2) the number of people in social network (C) is constant, and 3) individuals have perfect knowledge about the members of theirs active social network(Bernard et al., 2010) .

Although it is noted that real structures do not meet perfectly the assumptions of the method, many studies demonstrated that NSU could be reliable for estimating size of populations (Shokoohi et al., 2010; Ezoe et al., 2012).

Although almost all publications have been conducted on hard-to-reach populations like injected drug users (IDUs), female sex workers (FSWs), men who have sex with men (MSMs)(Shokoohi et al., 2010; Ezoe et al., 2012; Guo et al., 2013), a few works have discussed about using the method on non-hidden populations (low prevalent medical conditions) such as people living with some disabilities and the number of foreign body injuries in children (choked children) (Snidero et al., 2007; Mohebbi et al., 2014).

Exploring the method to estimate the size of cancer population as the most challenging issue in public health especially in determining the the size of population of diseases; and on the other hand, low prevalence of cancer is extremely dominant. Real benefit of NSU especially about sample size and publicly accessible persuaded us to explore whether NSU is applicable for estimating the size of the population of people living with breast, ovary and cervix, prostate, and bladder cancers or not.

Materials and Methods

Population

Iran, as a developing country in the Middle-East has 78 million population. A cross sectional study was conducted in Kerman city, the largest province of Iran with a population around 700,000. In this study, we selected of urban people more than 20 years old by simple sampling. A sample of 3052 was selected from capital of Kerman province.

We stratified the city to four zone based on government category and take equal number of samples from each zone (each zone has almost the same density of population). In each zone, only pedestrians were approached, the verbal constant was obtained before filling the questionnaire. Interviewers should select participants from different age and equal number of sex to get representative sample of the target population and also they did not have to take respondents from hospitals, organizations, stores and any especial places with a special members like sanatorium. There was no limitation on matching gender of respondents and interviewers. We chose the street-based interviewing because another separate study has shown that Iranian reply to questions more precise than home to home or telephone-based interviews (Haghdoost et al., 2013).

Demographic characteristics of respondents were also recorded as the second part of the questionnaire and the interviewers ensured them that all information were kept anonymity.

The Network Scale up (NSU) Method

NSU was first used as a method to estimate the victims of Mexican earthquake by sociologists and mathematicians (Russell et al., 1991). The method has been used and improved through the time to estimate hidden and non-hidden populations. However, using it in non-hidden population is relatively novel.

The NSU is based the members' social networks assumption saying that the proportion of the subpopulation of interest in each member of society social network is almost equal as the proportion of the subpopulation in whole society ($m/C=e/t$; where m is number of people known by respondents, C is the personal network size, e is the number of people of the subpopulation, and t is total population). In the other words, a sample of informant (the member of the society) provides the information about the subpopulation in their social network, indirectly. Hence, a small sample leads to large data set about all society which is easier and more cost-effective than direct methods (Jackson et al., 2005).

At first step of NSU is estimating the personal social network size of each individual, and then determining an average of social network (C) of the society. . In the present study, we used Iranian C, 308 persons, which was estimated in a separate study using known population size method (Rastegari et al., 2013).

To estimate m, respondents were questioned "whether they know anybody in their social network those suffering from breast or ovary-cervix or prostate or bladder cancers". The term "know" was defined as whom "you know them and they know you (face-to-face) or you have had interact and contact with them by telephone and email during last two years". Then, they asked to count them, "how many people do you know suffering from these cancers?"; the patients had to live in Kerman for the last five years (resident of Kerman city). Consequently, the figure e could be computed when the t is known (722,484

Network Scale-Up Method for Estimating Breast, Ovarian/Cervical, Prostate, and Bladder Cancers in Iran

based on national censuses in 2011).

Statistical analysis

Aggregating the replies of all respondents (3023 respondents), the basic formula to estimate the size of groups is (Equation 1):

$$\hat{e}_j = (t*\sum m_{ij})/\sum c_i \text{ (m summing over the subjects) (1)}$$

Here i and j stands for respondent and cancer type, and t is the total population of Kerman city (according to the latest official census in 2011: 722,484). Then the prevalence of the cancers was computed (per 100000).

Calculating incidence from cross-sectional prevalence

Although it is rarely estimated in cancer registries, prevalence is important to public health planning. When incidence data are not systemically recorded, it is often from surveys that incidence will be estimated.

To interpret our findings, we should convert prevalence to incidence because most of the documents have been reported incidence of the cancers. Since, the prevalence were divided by survival time of each cancer (the survival times were derived from Iranian documents) to calculate incidence (Vahdaninia and Montazeri, 2004; Arab et al., 2009; Rezaianzadeh et al., 2009; Heydari et al., 2012; Rezaianzadeh et al., 2012; Shamsnia et al., 2013)

Ethical consideration

The study protocol was approved and reviewed by research ethics committee of Kerman University of Medical sciences (No. K/91/34).

Results

We recruited 3052 (99% response rate) subjects with mean age of 33.21±10.35 were analyzed. Very scarce data like very low age and, regarding to age and gender and irrational responses were manually excluded. Our final sample included about equal numbers of male and female (50.5%) respondents. Moreover, more than half of them were married (63.5%) (Table 1).

A total of 1650 persons living with four types of cancers (breast, ovary/cervix, prostate, and bladder) were identified by respondents. Totally, the prevalence of people living with the four types of cancers was 228.37

Table 1. Demographic Characteristics of Respondents

Variable	Number (%)
Gender	
Male	1499 (49.5)
Female	1524 (50.5)
Marital Status	
Single	1019 (33.7)
Married	1920 (63.5)
Divorce/Widow	84 (2.8)
Formal Education (yrs.)	
<12	1493 (49.4)
12-16	1415 (46.8)
>16	117 (3.8)
Response rate	3023 (99.0)

Table 2. Number of People Identified by Respondents (mij), Prevalence and Incidence per 100000 Kermanian People, and Survival time of Breast, Ovarian/Cervical, Prostate, and Bladder Cancers

Site of cancer	m_{ij}	Prevalence* 100,000	Mean Survival time	Incidence* 100000
Breast	605	168.9	4.05	41.7
Ovary/Cervix	357	99.8	6.92	14.4
Prostate	426	116.9	4.05	28.9
Bladder	262	36.3	2.30	15.8
Total	1650	228.4	----------	---------

per 100000 of Kermanian inhabitants.

The most prevalent cancer was breast cancer, 168.9 per 100000, following that prostate cancer with 116.94, ovarian/cervical cancer 99.83, and bladder cancer 36.30 per 100000 Kerman city population.

Using survival time demonstrated that the incidence of breast cancer was the most one (41.70 per 100000 inhabitants), the second incident cancer was prostate cancer (28.87 per 100000), and then bladder cancer (15.78 per 100000), and ovarian/cervical cancer (14.42 per 100000) (Table 2).

Discussion

The purpose of this study was to explore if the NSU is applicable for estimating the population of people living with some cancers people (four types of cancer; breast, ovary/cervix, prostate, and bladder). The main finding was utilizing the method was almost appropriate, but it may be improved by modifying the method. We showed breast cancer the most prevalent cancer among Kermanian people where prostate is the second one, and bladder cancer was the least. Totally, it was shown that 228.37 per 100000 Kermanian people were suffered from the cancers in 2012-2013.

An epidemiological review of breast cancer in Iran (1998-2005) has reported the prevalence of the cancer 120 per 100000 and the incidence was 22 per 100000 (Mousavi et al., 2007). Moreover, Center for Disease Control and Prevention of Iran (2008) determined the incidence of breast cancer in Kerman at 12.61 per 100000 (ASR=16.40) (MOHME, 2009). Other surveys has been conducted and estimated the prevalence of breast cancer between 120 and 660 per 100000 (Talei et al., 1997; Asadi et al., 1999; Abbasalizadeh et al., 2002). The incidence of the breast cancer via NSU was very higher than other methods such as surveys, (41.70 *vs.* 6.8 and 8.1-11.8 per 100000) (Fallah, 2007; Mousavi et al., 2007; Fouladi et al., 2011). It seems that the method could be efficient but it should be considered that social networks may overlap in some cases. Designing more questions could adjust the answers and narrow them to more accurate one like "when was the diagnosis confirmed?" or "Does she/he under supervision of doctor?" or "Does she/he get chemotherapy?"

Ovarian/cervical cancers which are the forth common cancers among women was also estimated(Sharifian et al., 2014). The incidence of these cancers, wholly, was 14.42 per 100000 which was approximately far from national

report of Iran (2008), the crude rate was 2.13 (ASR=3.16) for cervical cancer and 1.5 (ASR=2.14) for ovarian cancer (MOHME, 2009). However, a study calculated 3.9 per 100000 incidence of ovarian cancer based on cancer registries data (pathology-based), during 2004-2005 (Arab et al., 2009) . We could not find any studies that reported the prevalence of the cancers but one reason of the higher value was combining two type of cancer (ovary and cervix), since such incidence rate is doubtful. Perhaps separating the cancers in the questionnaire could calculate more accurate incidence. Moreover, survival time of these cancers is almost different and generalizing each survival time to both could not be appropriate to measure the incidence.

Comparing incidence of prostate cancer of NSU (28.87 per 100000) with previous studies showed that it was obviously remarkably high (2-5.14 per 100000)(Sadjadi et al., 2007; Mousavi et al.,, 2009). Moreover, GLOBOCAN (2012) has estimated the incidence of prostate cancer of Iran as 10.84 per 100000 (4111 new cases in 2012) which was comparable with regional and national reports, but close to the NSU(Mousavi et al., 2007; Ferlay et al., 2013; Zahir et al., 2014).

The incidence (ASR) of bladder cancer was 9.65 for males and 3.27 for females , but NSU approach found 15.78 per 100000 (MOHME, 2009). On the other hand, comparing NSU prevalence with regional surveys showed an extensive variation (36.3 *vs*. 3.32-13.03 per 100000, respectively) (Salehi et al., 2011). Overestimation may due to misunderstanding the site of the cancers and respondents reported closer site like prostate instead of bladder or vice versa and combined them. Additionally, the enumeration of the cancerous people was due to guess not exactly enumerate the people as a result some of them account in more than one cancer or they guess that the people suffer from the cancer of interest without knowing about the accurate diagnosis. However, estimating the incidence of the cancer by gender could modify the value and make it more precise because the incidence of bladder cancer is considerably different between men and women.

Every methods in estimating population size has some assumption, in which deviate from each of them causes biases and errors, NSU is not exception. There are three major assumptions behind the NSU where violation from each of them causes some biases which are limited the utilization of NSU. Barrier effect happened when all members of the target population (the total population of Kerman province) have different chance of identifying the subgroup of interest (cancerous people) for instance those are working in oncology wards of hospitals, certainly they know more cancerous people. On the other hand, in the real world all people do not have perfect knowledge about their social network, so transmission effect occurred. The nature of human's mind is suffered from not reminding all data in short time (less than 30 seconds), as a result estimation effect (recall bias) is always happened when the methodology of research is based on reminding events (McCarty et al., 2001; Kadushin et al., 2006; Bernard et al., 2010). To overcome the estimation effect, we suggest that future studies exactly asked about the people who go to doctor because of her/his cancer. Hence, narrowing

questions by asking about treatment course, time of diagnosis, and their doctor's name could modify the method. However, in the present study when respondents could not remind anyone the interviewers helped them by asking more detailed questions to extract information from them.

In conclusion, Eventually, our results showed that the network scale up method estimates was approximately usable but not very precise way of estimating the size of subpopulations in the context of the four cancerous populations (breast, ovary/cervix, prostate, and bladder).

Acknowledgements

References

Abbasalizadeh S, Abbasalizadeh F, Sahaf F, et al (2002). Assessment of the prevalence of breast cancer in the Northwest of Tabriz. *Iran J Obstet Gynecol Infertility*, **5**, 54-7.

Arab M, Khayamzadeh M, Mohit M, et al (2009). Survival of ovarian cancer in Iran: 2000-2004. *Asian Pac J Cancer Prev*, **10**, 555-8.

Arab M, Khayamzadeh M, Tehranian A, et al (2010). Incidence rate of ovarian cancer in Iran in comparison with developed countries. *Indian J Cancer*, **47**, 322-7.

Asadi K, Owji M, Vahdat S, et al (1999). Breast cancer among 30-65 women in Boushehr. *Teb-e-Jonoub*, **1**, 217-22.

Bernard HR, Hallett T, Iovita A, et al (2010). Counting hard-to-count populations: the network scale-up method for public health. *Sex Transm Infect*, **86**, 11-5.

Ezoe S, Morooka T, Noda T, et al (2012). Population size estimation of men who have sex with men through the network scale-up method in Japan. *Plos one*, **7**, 31184.

Fallah M (2007). Cancer incidence in five provinces of iran: ardebil, gilan, mazandaran, golestan and kerman, 1996-2000.

Ferlay J, Soerjomataram I, Ervik M, et al (2013). GLOBOCAN 2012 v1. 0. Cancer incidence and mortality worldwide: *IARC CancerBase*.

Fouladi N, Amani F, Harghi AS, et al (2011). Five year survival of women with breast cancer in Ardabil, north-west of Iran. *Asian Pac J Cancer Prev*, **12**, 1799-801.

Guo W, Bao S, Lin W, et al (2013). Estimating the size of HIV key affected populations in Chongqing, China, using the network scale-up method. *PloS one*, **8**, 71796.

Haghdoost AA, Baneshi MR, Eybpoosh S, et al (2013). Comparison of three interview methods on response pattern to sensitive and non-sensitive questions. *Iran Red Crescent Med J*, **15**, 500.

Heydari S, Mehrabani D, Tabei S, et al (2012). Survival of breast cancer in southern Iran. *Iran J Cancer Prev*, **2**, 51-4.

Jackson D, Kirkland J, Jackson B, et al (2005). Social network analysis and estimating the size of hard-to-count subpopulations1. *Connect*, **26**, 49-60.

Kadushin C, Killworth PD, Bernard HR, et al (2006). Scale-up methods as applied to estimates of heroin use. *J Drug Issues*, **36**, 417-40.

Keyghobadi N, Rafiemanesh H, Mohammadian-Hafshejani A, et al (2015). Epidemiology and trend of cancers in the province of kerman: Southe Iran. *Asian Pac J Cancer Prev*, **16**, 1409-13.

McCarty C, Killworth PD, Bernard HR, et al (2001). Comparing two methods for estimating network size. *Human Organizat*, **60**, 28-39.

Mohebbi E, Baneshi MR, Haji-maghsoodi S, et al (2014). The application of network scale up method on estimating the prevalence of some disabilities in the Southeast of Iran. *J Res Health Sci*, **14**, 272-5.

Mousavi SM, Gouya MM, Ramazani R, et al (2009). Cancer incidence and mortality in Iran. *Ann Oncol*, **20**, 556-63.

Mousavi SM, Montazeri A, Mohagheghi MA, et al (2007). Breast cancer in Iran: an epidemiological review. *Breast J*, **13**, 383-91.

Parkin DM, Pisani P, Ferlay J (1999). Global cancer statistics. CA: *Cancer J Clin*, **49**, 33-64.

Rastegari A, Haji-Maghsoudi S, Haghdoost A, et al (2013). The estimation of active social network size of the Iranian population. *Global J Health Sci*, **5**, 217.

Rezaianzadeh A, Mohammadbeigi A, Mobaleghi J, et al (2012). Survival analysis of patients with bladder cancer, life table approach. *J Mid-Life Health*, **3**, 88.

Rezaianzadeh A, Peacock J, Reidpath D, et al (2009). Survival analysis of 1148 women diagnosed with breast cancer in Southern Iran. *BMC cancer*, **9**, 168.

Russell Bernard H, Johnsen EC, Killworth PD, et al (1991). Estimating the size of an average personal network and of an event subpopulation: Some empirical results. *Social Science Res*, **20**, 109-21.

Sadjadi A, Nooraie M, Ghorbani A, et al (2007). The incidence of prostate cancer in Iran: results of a population-based cancer registry. *Arch Iran Med*, **10**, 481-5.

Sadjadi A, Semnani S, Nouraie SM, et al (2008). Cancer registry in Iran: a brief overview. *Arch Iran Med*, **11**, 577.

Salehi A, Khezri AA, Malekmakan L, Aminsharifi A. (2011). Epidemiologic status of bladder cancer in Shiraz, southern Iran. *Asian Pac J Cancer Prev*, **12**, 1323-7.

Shamsnia SJ, Khezri AA, Tabbatabaei HR, et al (2013). Survival from Bladder Cancer in Shiraz, Southern Iran: A Hospital-Based Study. *Middle-East J Sci Res*, **18**, 425-31.

Sharifian A, Pourhoseingholi MA, Norouzinia M, et al (2014). Ovarian cancer in Iranian women, a trend analysis of mortality and incidence. *Asian Pac J Cancer Prev*, **15**, 10787.

Shokoohi M, Baneshi MR, Haghdoost AA (2010). Estimation of the active network size of kermanian males. *Addict Health*, **2**.

Snidero S, Morra B, Corradetti R, et al (2007). Use of the scale-up methods in injury prevention research: An empirical assessment to the case of choking in children. *Social Networks*, **29**, 527-38.

Talei AR, Sadeghi-Hassanabadi A, Salabian JA (1997). A preliminary report on breast cancer screening program in Shiraz Southern Iran. *Iran J Med Sci*, **22**, 148.

Vahdaninia M, Montazeri A (2004). Breast cancer in Iran: a survival analysis. *Asian Pac J Cancer Prev*, **5**, 223-5.

Veisy A, Lotfinejad S, Salehi K, et al (2015). Risk of breast cancer in relation to reproductive factors in North-west of Iran, 2013-2014. *Asian Pac J Cancer Prev*, **16**, 451.

Zahir ST, Nazemian MR, Zand S, et al (2014). Survival of patients with prostate cancer in Yazd, Iran. *Asian Pac J Cancer Prev*, **15**, 883-6.