ARCHIVES OF
IRANIAN MEDICINE

Open Access

Original Article

National and Subnational Trends of Incidence and Mortality of Female Genital Cancers in Iran; 1990–2016

Sahar Eftekharzadeh, MD, MPH[1]; Narges Ebrahimi, MSc[1]; Mehrnoosh Samaei, MD, MPH[1]; Farnam Mohebi, MD, MPH[1]; Bahram Mohajer, MD, MPH[1]; Ali Sheidaei, MSc[2]; Kimiya Gohari, MSc[3]; Sahar Saeedi Moghaddam, MSc[1]; Naser Ahmadi, MSc[1]; Sahar Mohammadi Fateh, MSc[1,4]; Fahimeh Ramezani Tehrani, MD[5]; Farshad Farzadfar, MD, MPH, MHS, DSc[1,4*]

[1]Non-Communicable Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran
[2]Department of Epidemiology and Biostatistics, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran
[3]Department of Biostatistics, Faculty of Medical Sciences, Tarbiat Modares University, Tehran, Iran
[4]Endocrinology and Metabolism Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran
[5]Reproductive Endocrinology Research Center, Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran

Abstract
Background: The present study aims to assess the incidence and mortality rates of gynecological cancers and their changes from 1990 to 2016 at national and subnational levels in Iran.
Methods: Annual estimates of incidence and mortality for gynecological cancers from 1990 to 2016 at national and subnational levels were generated as part of a larger project entitled National and Subnational Burden of Diseases, Injuries, and Risk Factors (NASBOD). After the precise processing of data extracted from the Iran Cancer Registry, annual age-standardized incidence and mortality rates were calculated for each cancer, province, year and age group during the period of the study.
Results: In 2016, gynecological cancers constituted 8.0% of new cancer cases among women of all ages compared to 3.7% of new cases of cancer among women in 1990. The incidence rate of gynecological cancers has increased from 2.5 (0.9-5.6) per 100 000 women in 1990 to 12.3 (9.3–15.7) per 100 000 women in 2016, and the most common gynecological cancer has changed from cervical cancer in 1990 to corpus uteri cancer in 2016. Age-standardized incidence rates of ovarian, corpus uteri and vulvovaginal cancers increased from 1.3 (0.5–2.4), 1.7 (0.6–3.0), and 0.3 (0.0–0.7) in 1990 to 4.4 (3.6–5.2), 9.9 (6.8–13.4), and 0.6 (0.2–1.0) in 2016, respectively, showing a 3.3, 5.8 and 1.7-fold increase during this period. Age-standardized incidence rate of cervical cancer was 2.4 (1.7–3.3) cases per 100 000 women in 2016 and did not differ significantly from the beginning of the study. An overall reduction was seen in national mortality to incidence ratios (MIR) from 2000 to 2015.
Conclusion: The incidence rates of all gynecological cancers in different provinces have shown a converging trend that could indicate that attempts toward health equality have been effective. The declining trend of MIR could be interpreted as advancements in detection of cancer in its early stages and also improvements in treatments, in turn reflecting improvements in access to and quality of care.
Keywords: Cervical neoplasms, Early detection of cancer, genital neoplasms, Ovarian neoplasms, Uterine neoplasms
Cite this article as: Eftekharzadeh S, Ebrahimi N, Samaei M, Mohebi F, Mohajer B, Sheidaei A, et al. National and subnational trends of incidence and mortality of female genital cancers in Iran; 1990–2016. Arch Iran Med. 2020;23(7):434–444. doi: 10.34172/aim.2020.40.

Introduction

Gynecological cancers, including neoplasms of the cervix, corpus uteri and ovaries, were responsible for 499,727 deaths among females globally in 2016 and accounted for 3.46% of deaths in women aged 15 to 59 years.[1] The mortality rates of gynecologic cancers show variations across the globe; in 2008, it was noted that about 75% of deaths due to this group of cancers had occurred in developing countries.[2] In 2012, cervical cancer was ranked the fourth most common cancer in females and the most common gynecological cancer around the globe with an estimated 527 624 new cases.[1] Cervical cancer incidence displays a socio-economic gradient, with a distinct difference between its incidence rates in Africa and North America. Cervical cancer bears a crucial importance in public health as it mostly affects young women of low socioeconomic status, demonstrating the extent of health inequities.[3] Healthcare inequities are even present in developed countries, as variations exist in the screening and vaccination coverage of cervical cancer among different regional, ethnic and racial groups.[4,5]

Although some studies have focused on time trends and regional disparities of gynecological cancers based on the national cancer registry,[6-10] there has not been a comprehensive analysis of trends of gynecological cancers in Iran at national and subnational levels. Furthermore,

*Corresponding Author: Farshad Farzadfar, MD, MPH, MHS, DSc; Non-Communicable Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, Jalal Al-e-Ahmad Highway, Tehran, Iran. Postal Code: 1411713137. Tel: +98-21-88631293; Email: f-farzadfar@tums.ac.ir

population-based studies on the epidemiology of gynecological cancers in Iran are out of date and incomplete, which further encouraged us to conduct this study.

As part of a larger project, in the present study, we aim to assess national and subnational incidence and mortality rates of gynecological cancers and their time trends from 1990 to 2016.

Material and Methods

Annual estimates of incidence for all cancers from 1990 to 2016 and estimates of mortality for all cancers from 1990 to 2015 at national and subnational level have been produced as part of the National and Subnational Burden of Diseases, Injuries, and Risk Factors (NASBOD) study.[11] In the NASBOD study, data regarding incidence cases of different cancers for years 2000 to 2010 were primarily obtained from the Iran Cancer Registry (except for the year 2006, which was not included in the database). Therefore, incidence data for years before 2000 and after 2010 needed to be extrapolated. The Social Security Organization Cancer Registry data and the Household Income and Expenditure Survey were used to assess rates of incompleteness in the main dataset and to provide necessary covariates for imputing missing data points and to complete Iran cancer registry data in the mentioned periods, after carefully omitting duplicated cases. For mortality data, we used different registries to obtain the most competent data; the sources are further discussed in references. Furthermore, mortality data from the death registry system was not available for the years 1990 to 1994 and 2005; therefore, mortality data for these years was extrapolated.[12]

For imputation of missing data, the Amelia package of R statistical software and the multinomial imputation method were applied. In order to extrapolate data for the years before 2000 and after 2010, the Random Intercept Mixed Effects model and Age-Spatio-Temporal model were developed. Methodological details of these procedures have been further discussed in previously published articles.[11-13] The observed to extrapolated data ratio in this study is 10.5%.

Data on cause-specific mortality rates have been previously collected and processed under the NASBOD study and details of the applied modeling methods and data processing have been fully explained in earlier studies.[12,13]

Cancers in this dataset are categorized based on the International Classification of Diseases version 10 (ICD-10). We extracted incidence data on all primary cancers that occurred at these sites: cervix (C.6.1), uterus (corpus uteri [C.6.2] and uterine [C.6.6]), ovary (C.6.4), vulvovaginal region (C.6.7 and C.6.8) and unspecified sites and others (C.6.3 merged with placenta [C.6.5]).

The extracted data were further analyzed to calculate annual crude incidence and mortality rates, age-standardized incidence rates (ASIR) and age-standardized mortality rates (ASMR) as well as mortality to incidence ratio (MIR) for all gynecological cancers; the 95% uncertainty interval was also calculated for all the estimates. To better understand the changes in incidence rates and mortality rates, the average annual percentage change (AAPC) throughout the study period was reported.

Furthermore, decomposition analysis was performed to estimate the effect of population growth and population aging on changes in incidence rates for corpus uteri, ovarian and cervical cancers at national and subnational levels. To achieve this goal, we calculated two scenarios: In the first scenario, population age structure and age specific incidence rates for each of the mentioned cancers among women in 1990 were applied to the population size of 2016. In the second scenario, age specific incidence rates for each of these three cancers in 1990 were applied to the 2016 age structure and population size. Several different decomposition methods have been presented in the literature;[14-17] the overall idea behind the method is presented in the following formula:

Overall-change = Population growth + Incidence rate changes + Age structure changes

STATA/MP software version 14.0 was used for all statistical analyses, and graphs and diagrams were generated by R statistical software, v.3.1.3.

Results

In 1990, gynecological cancers accounted for 3.7% of new cases of cancer among women; with an ASIR of 4.5 (95% UI: 1.9-8.1) cases per 100 000 women. In 2016, gynecological cancers contributed to 8.0% of all new cases of cancer among women. An increasing trend was observed from 1990 to 2016, leading to an ASIR of 12.3 (9.3–15.7) cases per 100 000 women in 2016 (Figures 1 and 2). The national AAPC during this period was 4%, while it ranged from 3% to 6% across the country (Table 1). Proportion of incidence by age groups and types were illustrated in Figure 3.

Cervical Cancer

Incident cases of cervical cancer increased from 264 new cases (102–453) in 1990 to 790 new cases (558–1053) in 2007. The number of new cases per year reached a plateau from 2007 to 2016 (range: 790–804 incident cases).

Furthermore, ASIR revealed a similar trend with an earlier peak in 2002, showing a 1.7–fold increase from 2.4 (1–4.1) to 4.1 (3.0–5.3) cases per 100 000 women from 1990 to 2002. From 2002 to 2016, ASIR declined from 4.1 to 2.4 (1.7–3.3) cases per 100 000 women.

Except for two provinces that saw increasing trends from 1990 to 2009 and stable rates thereafter, the highest
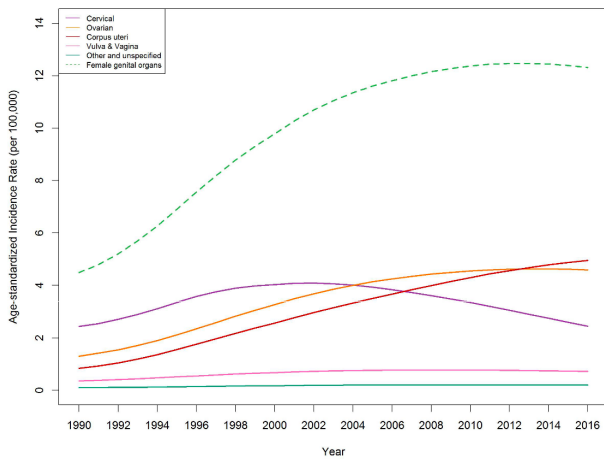
Figure 1. Trends in Age-Standardized Incidence Rates for Gynecological Cancers by Type, at National Level; 1990–2016.

In 1990, the highest provincial ASIR was approximately 10 times greater than the lowest provincial ASIR; this rate dropped to 4.5 in 2016.

Corpus Uteri Cancer

Both the number of new annual cases and incident rates of corpus uteri cancer displayed a consistent increasing pattern at the national level. The number of new cases increased from 121 (42–244) in 1990 to 2026 (1399–2737) in 2016 (Figure 2). Furthermore, ASIR indicated a similar time trend with a 5.8-fold increase from 1.7 (0.6–3.0) to 9.9 (6.8–13.4) during this period (Figure 1).

Nevertheless, analysis of data on a provincial level revealed a gradual mild to moderate inclination of incidence rates in all provinces, with an AAPC range of 5–10% among provinces, while the national AAPC during the study was 7% (Table 1).

Vulvovaginal Cancer

The number of new vulvovaginal cancer cases displayed a 5.7-fold increase from 46 cases in 1990 to 265 in 2016 (Figure 2). However, ASIR showed a slighter increase from 0.3 (0.0–0.7) in 1990 to 0.6 (0.2–1.0) cases per 100 000 women in 2000. From 2000 until 2016, the ASIR of vulvovaginal cancers remained the same (Figure 1).

Mortality of Gynecological Cancers

The ASMR for cervical cancer displayed an increasing trend from 1990 to 1997, rising from 2.5 (2.2–2.9) deaths per 100 000 women in 1990 to 3.7 (3.3–4.0) deaths per 100 000 women in 1997, and then a decreasing trend reaching 1.4 (1.2–1.5) in 2015 (Figure 4). On average, the

provincial ASIR was approximately 4.5-times bigger than the lowest provincial ASIR in 1990, while in 2016, the highest provincial ASIR was 5.7-times bigger than the lowest provincial ASIR.

Ovarian Cancer

The total number of incident cases of ovarian cancer has increased consistently from 219 (62–498) in 1990 to 1876 (1296–2525) new cases in 2016 (Figure 2).
ASIR showed an increasing trend from 1990 until 2008 with a 3.3-fold increase from 1.3 (0.5–2.4) to 4.4 (3.6–5.2) cases per 100 000 women. However, it demonstrated consistent rates from 2008 to 2016 without significant annual alterations. This trend was observed in all provinces.
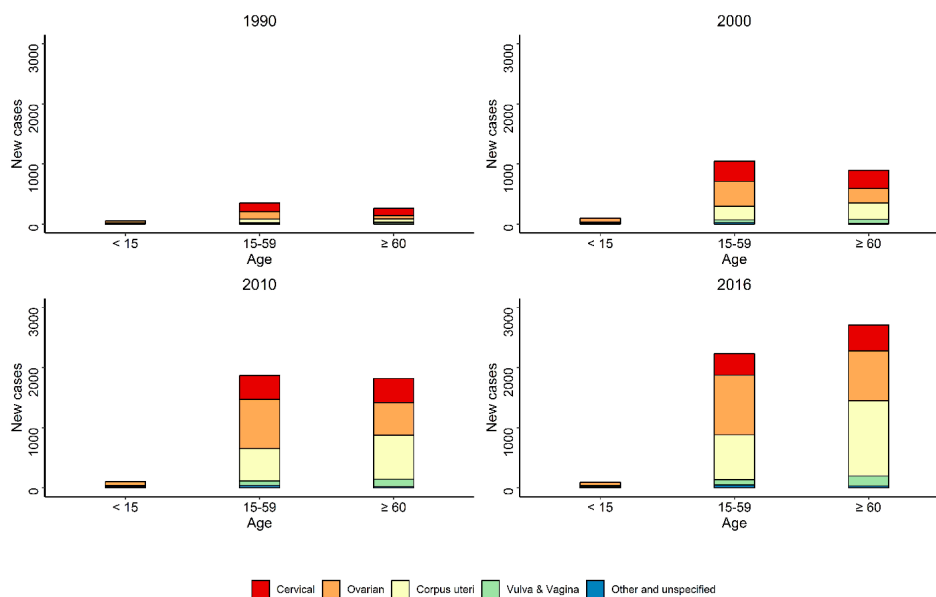

Figure 2. Age-Specific National Contributions of Cancer Types to Total Gynecological Cancer Incidence by Age Groups, at National Level; 1990, 2000, 2010 and 2016.

Table 1. The Average Annual Percent Changes in Gynecological Cancers' Incidence and Mortality Rates, Overall and by Type, at National and Provincial Level in Iran; 1990–2016

Location	All Gynecological Cancers	Cervical Cancer		Ovarian Cancer		Corpus Uteri Cancer		Vulvaginal Cancer
	Incidence (%)	Incidence (%)	Mortality (%)	Incidence (%)	Mortality (%)	Incidence (%)	Mortality (%)	Incidence (%)
National	4	0	-2	5	-3	7	-14	3
Alborz	3	1	-1	4	2	6	-14	3
Khorasan, South	4	0	0	5	-2	8	-12	2
Khorasan, North	4	1	-1	7	-2	9	-14	2
Golestan	4	2	0	4	-1	8	-13	4
Qazvin	5	2	-3	5	0	8	-13	3
Qom	4	0	-3	5	-2	7	-14	3
Ardabil	4	-1	-2	6	-3	8	-13	0
Tehran	3	-1	-5	4	-4	5	-17	4
Hormozgān	4	4	2	3	2	8	-10	5
Yazd	4	0	-2	5	-2	7	-13	3
Semnan	5	2	-1	4	0	8	-13	3
Zanjan	3	-4	-5	11	-5	8	-15	-2
Bushehr	4	2	0	3	1	7	-11	5
Kohgiluyeh and Boyer-Ahmad	5	0	-2	6	-1	10	-14	1
Ilam	4	2	-1	5	0	9	-12	2
Lorestan	4	-2	-4	7	-5	8	-14	0
Chahar Mahaal and Bakhtiari	4	-1	0	5	-2	8	-11	3
Hamadan	5	1	-2	5	-1	9	-12	3
Kordestan	4	-1	-2	8	-3	10	-14	1
Sistan and Baluchistan	4	0	-3	7	-4	8	-14	1
Isfahan	4	1	-1	4	-2	7	-13	4
Khorasan, Razavi	4	1	-3	5	-6	9	-16	3
Kerman	4	-1	-2	6	-3	8	-14	2
Fars	4	0	-1	4	-2	7	-14	3
Khuzestan	4	1	0	5	-1	7	-12	3
Kermanshah	4	0	-1	5	-2	8	-13	3
Azerbaijan, West	5	-1	-3	7	-5	9	-15	1
Azerbaijan, East	4	-1	-3	6	-3	8	-15	1
Mazandaran	4	-1	-3	6	-4	8	-16	1

cervical cancer mortality rate in Iran increased by 18.0% (13.8–22.3) annually between 1990 and 1997 and then showed an average annual 12.8% (11.9–13.7) decrease between 1997 and 2015 (Figures 5 and 6).

The ASMR of ovarian cancer slightly rose between 1990 and 1995, rising from 2.2 (1.9–2.5) to 3.0 (2.7–3.3) deaths per 100 000 women and then showed a consistent declining trend, reaching 1.0 (0.9–1.2) deaths per 100 000 women in 2015. The ASMR of corpus uteri cancer showed a declining trend during the study, dropping from 6.5

(6.0–7.1) deaths per 100 000 women in 1990 to 0.1 (0.1–0.2) deaths per 100 000 women in 2015.

National MIRs for cervical, ovarian and corpus uteri cancers showed declines of 36.0%, 69.8% and 97.3% between the years 2000 and 2015, respectively (Figure 7).

Decomposition Analysis
Decomposition analysis showed that changes in age specific incidence rates contributed to 88% and 81% of the increase in incidence rates of corpus uteri and ovarian
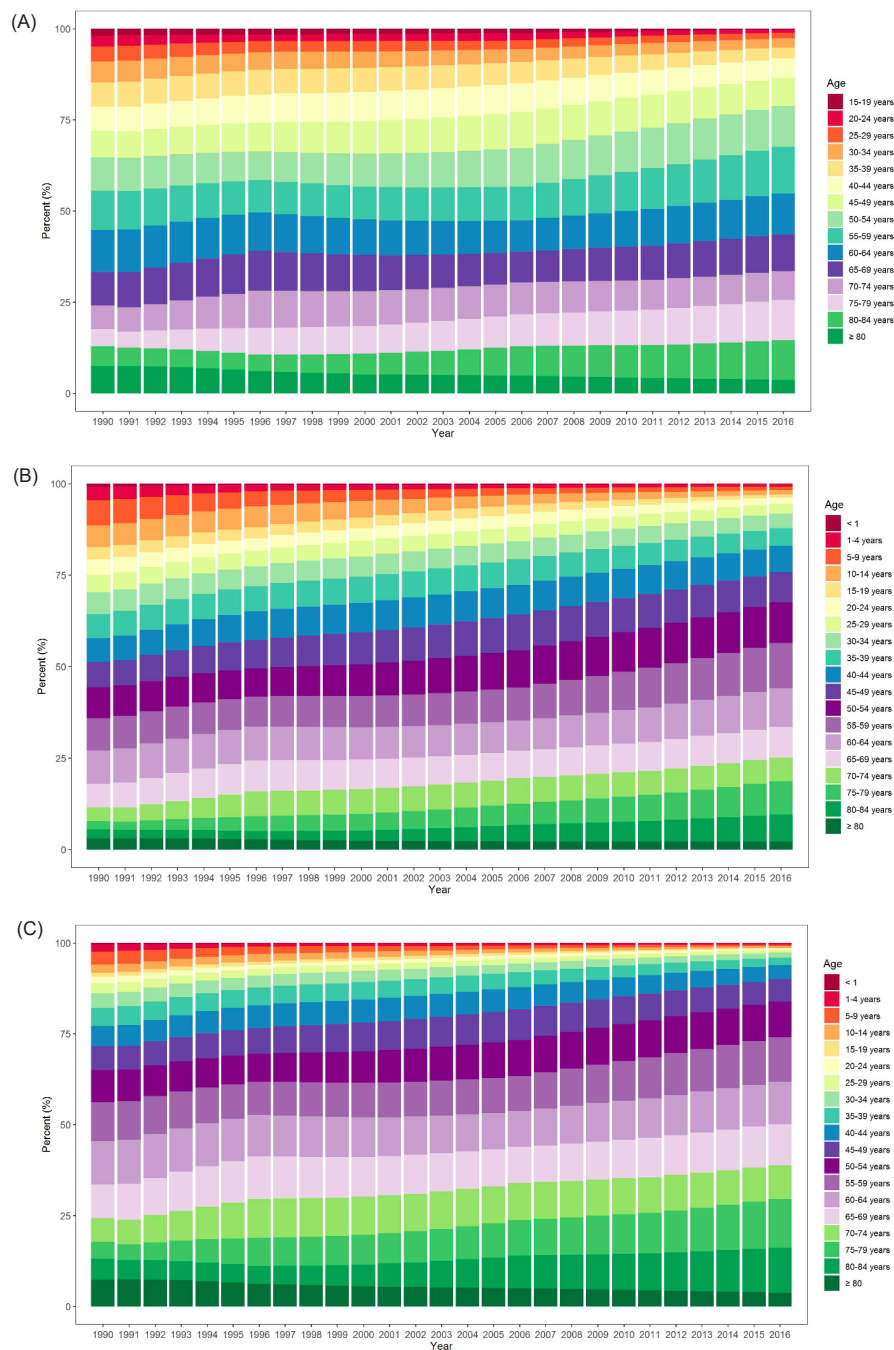
Figure 3. Contribution of Age Groups to Cervical (**A**), Ovarian (**B**), and Corpus Uteri (**C**) Cancer Incidence in Iran; 1990–2016.

cancers, respectively. Furthermore, population growth and aging contributed to 3.5% and 8.3% of the rise in incidence rates of corpus uteri cancer and 7.3% and 12% of the rise in incidence rates of ovarian cancer, respectively (Tables 2 and 3).

In the case of cervical cancer, the alterations in incidence rate were mainly due to population growth, which contributed to 61.4% of the overall change. Moreover, changes in age structure attributed to 38.0% of the overall change, while changes in age specific incidence rates were responsible for less than 1% of the total change in incidence rate (Table 4).

Discussion

In the present study, we provided an overview of national and subnational incidence and mortality rates as well as trends of different categories of gynecological cancers from 1990 to 2016, demonstrating rising trends in the incidence rates of corpus uteri, ovarian and vulvovaginal cancers throughout the study. The results of this study show that national MIR, an indicator of access to and quality of care, have declined for all gynecological cancers between 2000 and 2015.

During this study, cervical cancer incidence showed an increasing trend from 1990 to 2004 , and then following
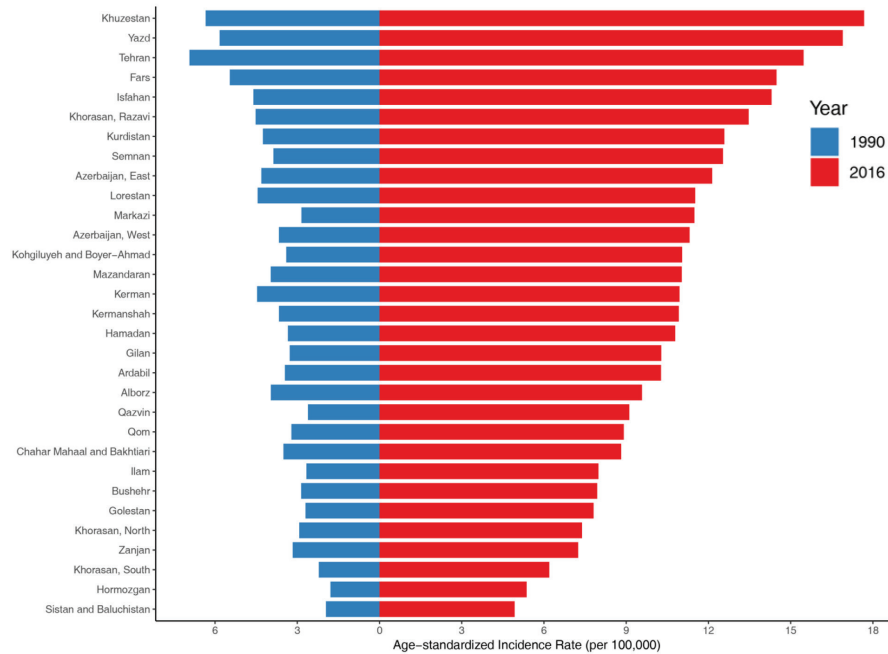
Figure 4. Age-Standardized Incidence Rates for Gynecological Cancers by provinces in 1990 (left) and 2016 (right).
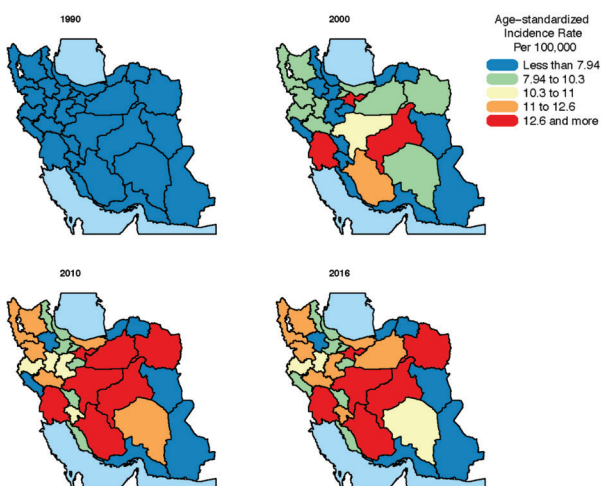

Figure 5. Map of Age-Standardized Incidence Rates for Gynecological Cancers by Provinces in 1990, 2000, 2010, and 2016.

a 5-year period of steady rates (between 2004 and 2009), the incidence rates declined until 2016, which could be associated with the onset of the national screening program using Pap smears in the 1990s. However, the starting point of this declining trend varied across the country, possibly due to unequal healthcare coverage among the provinces, as well as disparities among the provinces in compliance to regular screening and necessary treatments. The trend observed in this study was in accordance with the data provided by the Institute for Health Metrics and Evaluation (IHME). However, in the IHME report, the incidence of cervical cancer had a steady trend between 1990 and 2012 and a declining trend in incidence was not

observed until 2013.[18,19] In the present study, more data points were used than IHME.

Moreover, we observed an increasing incidence of ovarian cancer from 1990 to 2008 and steady rates afterwards. However, incidence rates had a linear increasing trend until 2016 in the IHME report, reaching a similar incidence rate in 2016 – as presented in this study.[18] The uterine cancer trend reported by the IHME is similar to ours; however, the incidence rates were underestimated in the IHME report.[19,20] The rising trends of uterine and ovarian cancer in Iran can be explained by lifestyle changes in the past three decades, for instance, the rise of obesity prevalence and increased age of first childbirth.[20-22]

The main strength of this study was benefitting from different national datasets for cancer incidences and mortalities and establishing a statistical model to resolve issues such as incompleteness of data. Although the observed to extrapolated data ratio in this study is not high, it is acceptable compared to previous ratios in international studies; for instance 5.6% in a cholesterol study,[23] 16.6% in a study on BMI[24] and 13.6% in a study on systolic blood pressure.[25]

As both data of incidence and mortality before the year 2000 were not real data and were extrapolated, the MIR, which is a computational measure, was not reliable before 2000. Therefore, MIR values were only reported after 2000 to be more precise and dependable. Although statistical models have been applied to omit the effects of missing data, junk codes and misalignments, the necessity for a higher quality national cancer registry with better coverage should not be overlooked. Furthermore, lack of reports on the coverage of the cervical cancer screening
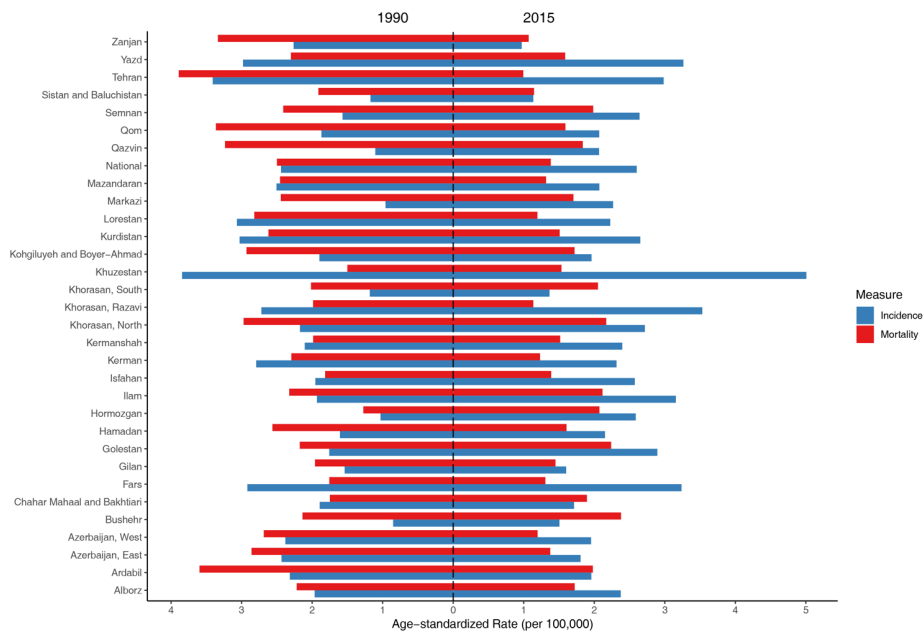
Figure 6. Estimated Cervical Cancer Age-Standardized Incidence and Mortality Rates in Different Provinces of Iran in 1990 (Left) and 2015 (Right).

program at subnational and national levels may leave us with some doubts concerning the influence of the cervical cancer screening program on the incidence and mortality rates. Another limitation that we faced was the sparsity of covariates that were included in the cancer registry, leading to restrictions in investigating the risk factors influencing the incidence of specific cancers.

The introduction of the Papanicolaou (Pap) test as a screening tool for cervical cancer (which is currently acknowledged as the most effective tool for controlling this cancer) has affected the incidence of this neoplasia differently across countries and regions.[5] Cervical cancer screening programs have been initiated in several countries starting from the 1970s and have affected mortality and

Figure 7. Trends in Mortality to Incidence Ratio for Cervical Cancer, Corpus Uteri Cancer and Ovarian Cancer at National Level; 2000–2015.

morbidity rates of cervical cancer globally; yet in many middle-income developing countries, ongoing programs are not succeeding.[26] The first cervical cancer screening program guideline in Iran was established in 1990. It was an opportunistic screening program that encouraged women aged 20-65 years to take a free Pap smear test annually for cytology when visiting public health clinics for routine health checkups or for maternal-child health and family planning services. After conducting a cost-effective study on this guideline, the policy toward cervical cancer screening changed and the Pap smear screening was eliminated from the public health services' coverage in 2000.[27] In the first years following the initiation of the national screening of cervical cancer, an increase in incidence was detected, probably due to the increase in detection of unknown cases of cervical cancer. Following this period, we can see the impact of the screening program leading to a steady trend and then a mild decline afterwards, probably due to the detection of pre-cancerous lesions. Although the national screening program was ceased in 2000, some insurance companies still partially covered the expenses of Pap smear cytology assessment and women could receive screening tests upon their own request or in case their health-care provider recommended it.[28] Recent studies suggest that a shift from Pap smear to HPV DNA testing for cervical cancer screening would be beneficial in Iran, considering its convenience and effectiveness as well as its cost-effectiveness.[29,30] According to a cost-effectiveness analysis study conducted in Iran, starting at the age of 35 years, and at 5-years intervals, HPV DNA testing would be the most cost-effective screening technique based on national incidence rates and incomes.[31] It is also important
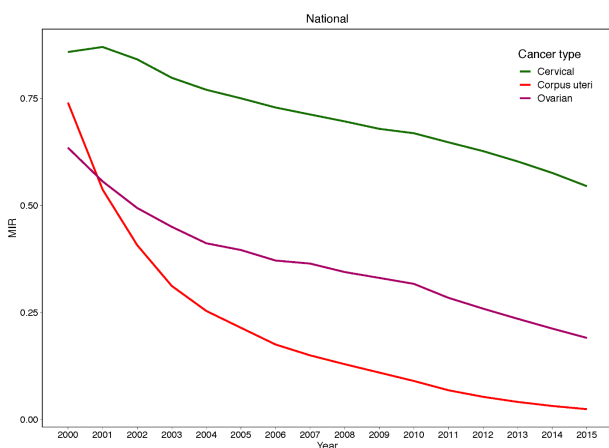
Table 2. Decomposition Analysis of Corpus Uteri Cancer Trends of National and Subnational Incidences; 1990–2016

Location	Change in Incident Cases, 1990 to 2016, %			Overall Change, No.	Contribution to Change in Incident Cases, 1990 to 2016,%		
	Due to Population Growth	Due to Change in Age Structure	Due to Change in Incident Rates		Due to Population Growth	Due to Change in Age Structure	Due to Change in Incident Rates
National	0.6	1.3	14	16	3.5	8.3	88
Alborz	1.6	2.3	15	19	8.7	12	79
Ardabil	0.2	1.1	16	17	1.1	6.4	93
Azerbaijan, East	0.2	1.2	14	15	1.6	7.7	91
Azerbaijan, West	0.5	1.4	27	29	1.9	4.7	93
Bushehr	0.7	1.1	12	14	5.1	8.2	87
Chahar Mahaal and Bakhtiari	0.4	1.3	15	17	2.1	7.9	90
Fars	0.5	1.4	13	15	3.3	9	88
Gilan	0.3	1.2	16	17	1.4	7.1	92
Golestan	0.6	1.2	16	18	3.3	6.8	90
Hamadan	0.2	1.2	18	20	0.96	6.1	93
Hormozgan	1.1	1.0	19	21	5.1	4.5	90
Ilam	0.4	1.2	22	24	1.9	5.1	93
Isfahan	0.5	1.3	14	16	3.3	8.1	89
Kerman	0.9	1.3	18	20	4.6	6.2	89
Kermanshah	0.4	1.5	21	23	1.6	6.4	92
Khorasan, North	0.4	1.1	19	21	2.2	5.3	92
Khorasan, Razavi	0.5	1.2	20	22	2.3	5.7	92
Khorasan, South	0.1	0.9	14	15	1	5.6	93
Khuzestan	0.7	1	14	16	4.4	6.4	89
Kohgiluyeh and Boyer-Ahmad	0.6	1.2	29	31	1.8	4	94
Kurdistan	0.4	1	25	26	1.4	3.9	95
Lorestan	0.3	1.3	16	18	1.7	7.4	91
Markazi	0.3	1.2	29	31	1.1	3.9	95
Mazandaran	0.4	1.3	16	17	2.2	7.3	90
Qazvin	0.5	1.3	20	21	2.3	6	92
Qom	0.8	1.1	13	15	5.2	7	88
Semnan	0.6	0.9	15	16	3.5	5.7	91
Sistan and Baluchistan	1.0	0.7	17	18	5.6	3.7	91
Tehran	0.8	1.6	8.8	11	6.9	14	79
Yazd	0.7	1.3	16	18	4	7	89
Zanjan	0.3	0.9	15	16	2	5.7	92

to notice the declining pattern of MIR for gynecological cancers, which could be explained by an increase in their early detection and better survival due to better access to treatment and better quality of care.

Since cervical cancer is an HPV-related cancer, population coverage with HPV vaccine can also result in reduction of its incidence and mortality, as observed in high-income societies with high-prevalence of cervical cancer, for instance, New Zealand, Canada and Denmark.[4,32-34] However, studies in Iran have shown that due to the high

cost of HPV vaccination and the low incidence of cervical cancer, a national obligatory vaccination program would not be cost-effective: in countries like Iran, an organized screening program would be more effective.[35-37]

In conclusion, this study presents the gynecological cancer profile in general as well as each specific cancer in Iran from 1990 to 2016, depicting the rising trends in incidence of gynecological cancers, specifically ovarian and uterine cancers. Furthermore, it assessed disparities among provinces by observing the trends of incidences

Table 3. Decomposition Analysis of Ovarian Cancer Trends of National and Subnational Incidences; 1990–2016

Location	Change in Incident Cases, 1990 to 2016, %			Overall Change, No.	Contribution to Change in Incident Cases, 1990 to 2016,%		
	Due to Population Growth	Due to Change in Age Structure	Due to Change in Incident Rates		Due to Population Growth	Due to Change in Age Structure	Due to Change in Incident Rates
National	0.6	0.9	6.1	7.6	7.3	12	81
Alborz	1.6	1.7	6.8	10	16	17	67
Ardabil	0.2	0.6	7.3	8.1	2.2	7.5	90
Azerbaijan, East	0.2	0.7	6.4	7.4	3.4	9.3	87
Azerbaijan, West	0.5	0.7	12	13	4.2	5.5	90
Bushehr	0.7	0.9	3.3	5	14	19	67
Chahar Mahaal and Bakhtiari	0.4	0.9	6.1	7.4	4.9	12	83
Fars	0.5	0.9	4.8	6.2	8.1	15	77
Gilan	0.2	0.9	5.6	6.7	3.6	13	83
Golestan	0.6	0.8	4.8	6.2	9.4	13	78
Hamadan	0.2	0.8	5.6	6.6	2.9	12	85
Hormozgan	1.1	0.8	2.6	4.5	24	17	58
Ilam	0.4	0.8	6.1	7.4	6	11	83
Isfahan	0.5	1.0	4.9	6.4	8.2	15	76
Kerman	0.9	0.8	8.4	10	9.1	7.6	83
Kermanshah	0.4	0.9	6.8	8.1	4.5	11	84
Khorasan, North	0.4	0.5	10	11	4	4.8	91
Khorasan, Razavi	0.5	0.8	6.3	7.6	6.5	11	83
Khorasan, South	0.1	0.6	5	5.8	2.7	9.8	88
Khuzestan	0.7	0.8	5.6	7	10	11	79
Kohgiluyeh and Boyer-Ahmad	0.6	0.9	9.2	11	5.4	8.2	86
Kurdistan	0.4	0.5	13	14	2.8	3.9	93
Lorestan	0.3	0.6	9.5	10	2.9	6.2	91
Markazi	0.3	0.9	5	6.3	5.3	15	80
Mazandaran	0.4	0.8	8.2	9.4	4.1	8.8	87
Qazvin	0.5	0.9	5.4	6.9	7.2	14	79
Qom	0.8	0.8	6.6	8.2	9.7	10	80
Semnan	0.6	0.7	4.2	5.5	10	13	76
Sistan and Baluchistan	1.0	0.3	8.1	9.5	11	3.4	86
Tehran	0.8	1.1	5.1	6.9	11	16	73
Yazd	0.7	0.8	6.1	7.7	9.3	11	80
Zanjan	0.3	0.2	23	24	1.4	0.95	98

and mortalities over time, which showed a converging pattern, indicating advancements toward health equality.

The results provided by the current study can be beneficial for policy-makers in evaluating earlier screening program guidelines as well as other executive plans to decrease the effects of known risk factors for gynecological cancers.

Table 4. Decomposition Analysis of Cervical Cancer Trends of National and Subnational Incidences; 1990–2016

Location	Change in Incident Cases, 1990 to 2016, %			Overall Change, No.	Contribution to Change in Incident Cases, 1990 to 2016,%		
	Due to Population Growth	Due to Change in Age Structure	Due to Change in Incident Rates		Due to Population Growth	Due to Change in Age Structure	Due to Change in Incident Rates
National	1.22	0.76	0.01	1.99	61.38	38.05	0.57
Alborz	2.8	1.43	0.54	4.76	58.71	30.03	11.26
Ardabil	0.81	0.63	-0.52	0.92	87.74	68.41	-56.15
Azerbaijan, East	0.75	0.78	-0.81	0.73	103.71	107.84	-111.54
Azerbaijan, West	1.2	0.85	-0.73	1.32	91.11	64.08	-55.18
Bushehr	1.44	0.56	1.96	3.96	36.44	14.19	49.37
Chahar Mahaal and Bakhtiari	1.06	0.79	-0.52	1.33	79.54	59.46	-39
Fars	1.25	0.74	0.1	2.09	59.81	35.41	4.78
Gilan	0.72	0.81	0.03	1.56	46.23	51.94	1.83
Golestan	1.29	0.67	1.67	3.64	35.48	18.48	46.04
Hamadan	0.78	0.74	0.68	2.21	35.53	33.63	30.83
Hormozgan	2.06	0.27	4.61	6.94	29.67	3.96	66.37
Ilam	1.38	0.58	1.55	3.51	39.22	16.57	44.22
Isfahan	1.18	0.78	0.79	2.74	42.98	28.29	28.73
Kerman	1.77	0.64	-0.9	1.51	117.15	42.34	-59.49
Kermanshah	1.04	0.93	0.22	2.19	47.45	42.34	10.21
Khorasan, North	1.09	0.64	0.37	2.11	51.69	30.54	17.77
Khorasan, Razavi	1.14	0.74	0.6	2.48	46.01	29.91	24.08
Khorasan, South	0.56	0.58	0.11	1.25	44.55	46.51	8.95
Khuzestan	1.54	0.38	0.6	2.52	61.08	15.17	23.75
Kohgiluyeh and Boyer-Ahmad	1.51	0.56	-0.19	1.88	80.41	29.83	-10.24
Kurdistan	1.09	0.54	-0.57	1.06	102.8	51.33	-54.12
Lorestan	1.05	0.76	-0.97	.83	125.55	90.74	-116.29
Markazi	0.9	0.75	3.33	4.98	18.11	15.09	66.8
Mazandaran	0.94	0.85	-0.59	1.21	77.88	70.84	-48.71
Qazvin	1.2	0.78	2.27	4.25	28.28	18.28	53.44
Qom	1.56	0.54	0.05	2.15	72.71	24.93	2.36
Semnan	1.13	0.48	1.62	3.23	35.05	14.99	49.96
Sistan and Baluchistan	1.81	0.35	-0.47	1.69	107.45	20.47	-27.93
Tehran	1.38	1.12	-0.62	1.89	73.04	59.52	-32.57
Yazd	1.36	0.8	0.16	2.31	58.61	34.57	6.83
Zanjan	0.99	0.55	-1.61	-0.08	-1265.57	-696.79	2062.36

References
1. Global Health Data Exchange. Global Burden of Disease Study 2016 Results. Available from: http://ghdx.healthdata.org/gbd-results-tool.
2. Ferlay J, Shin HR, Bray F, Forman D, Mathers C, Parkin DM. Cancer incidence and mortality worldwide: GLOBOCAN 2008 v2.0. Lyon, France: International Agency for Research. 2010. Report No.: IARC CancerBase No. 10.
3. Arbyn M, Castellsagué X, de Sanjosé S, Bruni L, Saraiya M, Bray F, et al. Worldwide burden of cervical cancer in 2008. Ann Oncol. 2011;22(12):2675-86. doi: 10.1093/annonc/mdr015.
4. Smith MA, Edwards S, Canfell K. Impact of the National Cervical Screening Programme in New Zealand by age: analysis of cervical cancer trends 1985–2013 in all women and in Māori women. Cancer Causes Control. 2017;28(12):1393-1404. doi: 10.1007/s10552-017-0967-y.
5. Yoo W, Kim S, Huh WK, Dilley S, Coughlin SS, Partridge EE, et al. Recent trends in racial and regional disparities in cervical cancer incidence and mortality in United States. PLoS One. 2017;12(2): e0172548. doi: 10.1371/journal.pone.0172548.
6. Khorasanizadeh F, Hassanloo J, Khaksar N, Taheri SM, Marzaban M, Rashidi BH, et al. Epidemiology of cervical cancer and human

papilloma virus infection among Iranian women — Analyses of national data and systematic review of the literature. Gynecol Oncol. 2013;128(2):277-81. doi: 10.1016/j.ygyno.2012.11.032.

7. Arab M, Khayamzadeh M, Tehranian A, Tabatabaeefar M, Hosseini M, Anbiaee R, et al. Incidence rate of ovarian cancer in Iran in comparison with developed countries. Indian J Cancer. 2010;47(3):322. doi: 10.4103/0019-509X.64721.

8. Arab M, Noghabaei G. Comparison of Age- Standard Incidence Rate Trends of Gynecologic and Breast Cancer in Iran and Other Countries. Iran J Public Health. 2014;43(10):1372-1379.

9. Sharifian A, Pourhoseingholi MA, Norouzinia M, Vahedi M. Ovarian cancer in Iranian women, a trend analysis of mortality and incidence. Asian Pac J Cancer Prev. 2014;15(24):10787-90. doi: 10.7314/apjcp.2014.15.24.10787.

10. Arab M, Noghabaei G, Kazemi SN. Comparison of crude and age-specific incidence rates of breast, ovary, endometrium and cervix cancers in Iran, 2005. Asian Pac J Cancer Prev. 2014;15(6):2461-4. doi: 10.7314/apjcp.2014.15.6.2461.

11. Farzadfar F, Delavari A, Malekzadeh R, Mesdaghinia A, Jamshidi HR, Sayyari A, et al. NASBOD 2013: Design, definitions, and metrics. Arch Iran Med. 2014;17(1):7-15.

12. Sheidaei A, Gohari K, Kasaeian A, Rezaei N, Mansouri A, Khosravi A, et al. National and subnational patterns of cause of death in Iran 1990–2015: applied methods. Arch Iran Med. 2017;20(1):2-11.

13. Mohammadi Y, Parsaeian M, Farzadfar F, Kasaeian A, Mehdipour P, Sheidaei A, et al. Levels and trends of child and adult mortality rates in the Islamic Republic of Iran, 1990-2013; protocol of the NASBOD study. Arch Iran Med. 2014;17(3):176-81.

14. Peterson PL, Marx RW, Clark CM. Teacher planning, teacher behavior, and student achievement. Am Educ Res J. 1978;15(3):417-32. doi: 10.3102/00028312015003417.

15. Arriaga EE. Measuring and explaining the change in life expectancies. Demography. 1984;21(1):83-96.

16. Pollard JH. Some methodological issues in the measurement of sex mortality patterns. School of Economics and Financial Studies, Macquarie University; 1981.

17. Basu S, Hong A, Siddiqi A. Using decomposition analysis to identify modifiable racial disparities in the distribution of blood pressure in the United States. Am J Epidemiol. 2015;182(4):345-53. doi: 10.1093/aje/kwv079.

18. Institute for Health Metrics and Evaluation (IHME). GBD Compare Data Visualization. 2017. Available from: https://vizhub.healthdata.org/gbd-compare/.

19. Sadjadi A, Malekzadeh R, Derakhshan MH, Sepehr A, Nouraie M, Sotoudeh M, et al. Cancer occurrence in Ardabil: Results of a population-based Cancer Registry from Iran. Int J Cancer. 2003;107(1):113-8. doi: 10.1002/ijc.11359.

20. Stevens GA, Singh GM, Lu Y, Danaei G, Lin JK, Finucane MM, et al. National, regional, and global trends in adult overweight and obesity prevalences. Popul Health Metr. 2012;10:22. doi: 10.1186/1478-7954-10-22.

21. Malekzadeh R, Mohamadnejad M, Merat S, Pourshams A, Etemadi A. Obesity pandemic: an Iranian perspective. Arch Iran Med. 2005;8(1):1-7.

22. Ranjbar F, Shirzad M, Kamali K, Akhondi MM, Ghoodjani A, Ardakani ZB, et al. Fertility behaviour of Iranian women: a community-based, cross-sectional study. Arch Iran Med. 2015;18(1):2-5.

23. Farzadfar F, Finucane MM, Danaei G, Pelizzari PM, Cowan MJ, Paciorek CJ, et al. National, regional, and global trends in serum total cholesterol since 1980: systematic analysis of health examination surveys and epidemiological studies with 321 country-years and 3.0 million participants. Lancet.

2011;377(9765):578-86. doi: 10.1016/S0140-6736(10)62038-7.

24. Finucane MM, Stevens GA, Cowan MJ, Danaei G, Lin JK, Paciorek CJ, et al. National, regional, and global trends in body-mass index since 1980: systematic analysis of health examination surveys and epidemiological studies with 960 country-years and 9.1 million participants. Lancet. 2011;377(9765):557-67. doi: 10.1016/S0140-6736(10)62037-5.

25. Danaei G, Finucane MM, Lin JK, Singh GM, Paciorek CJ, Cowan MJ, et al. National, regional, and global trends in systolic blood pressure since 1980: systematic analysis of health examination surveys and epidemiological studies with 786 country-years and 5·4 million participants. Lancet. 2011;377(9765):568-77. doi: 10.1016/S0140-6736(10)62036-3.

26. Aminisani N, Armstrong BK, Canfell K. Cervical cancer screening in Middle Eastern and Asian migrants to Australia: a record linkage study. Cancer Epidemiol. 2012;36(6):e394-400. doi: 10.1016/j.canep.2012.08.009.

27. Behmard S, Taherzadeh D, Gondos BJAc. Cytologic screening for cervical cancer in southern Iran. 1977;21(3):432-4.

28. Khodakarami N, Farzaneh F, Yavari P, Khayamzadeh M, Taheripanah R, Esmaeil Akbari M. The new guideline for cervical cancer screening in low risk Iranian women. Iranian Journal of Obstetrics, Gynecology and Infertility. 2014;17(95):8-17.

29. Cox JT. History of the use of HPV testing in cervical screening and in the management of abnormal cervical screening results. J Clin Virol. 2009;45 Suppl 1:S3-12. doi: 10.1016/S1386-6532(09)70002-2.

30. Cuzick J, Sasieni P, Davies P, Adams J, Normand C, Frater A, et al. A systematic review of the role of human papilloma virus (HPV) testing within a cervical screening programme: summary and conclusions. Br J Cancer. 2000;83(5):561-5. doi: 10.1054/bjoc.2000.1375.

31. Nahvijou A, Daroudi R, Tahmasebi M, Amouzegar Hashemi F, Rezaei Hemami M, Akbari Sari A, et al. Cost-effectiveness of different cervical screening strategies in Islamic Republic of Iran: a middle-income country with a low incidence rate of cervical cancer. PLoS One. 2016;11(6):e0156705. doi: 10.1371/journal.pone.0156705.

32. Markowitz LE, Hariri S, Lin C, Dunne EF, Steinau M, McQuillan G, et al. Reduction in human papillomavirus (HPV) prevalence among young women following HPV vaccine introduction in the United States, National Health and Nutrition Examination Surveys, 2003–2010. J Infect Dis. 2013;208(3):385-93. doi: 10.1093/infdis/jit192.

33. Markowitz LE, Tsu V, Deeks SL, Cubie H, Wang SA, Vicari AS, et al. Human papillomavirus vaccine introduction–the first five years. Vaccine.2012;30 Suppl 5:F139-48. doi: 10.1016/j.vaccine.2012.05.039.

34. Fitzgerald N, Hussain S, Memon S, Gauvreau C, Flanagan W, Nadeau C, et al. Evaluating clinical and cost impacts of achieving 90% HPV vaccination rate against cervical cancer in Canada using the OncoSim Cancer Simulation Model. J Glob Oncol. 2018. doi: 10.1200/jgo.18.27600

35. Khatibi M, Rasekh HR, Shahverdi Z. Cost-effectiveness evaluation of quadrivalent human papilloma virus vaccine for HPV-related disease in Iran. Iran J Pharm Res. 2014;13(Suppl):225-34.

36. Yaghoubi M, Nojomi M, Vaezi A, Erfani V, Mahmoudi S, Ezoji K, et al. Cost-effectiveness analysis of the introduction of HPV vaccination of 9-year-old-girls in Iran. Value Health Reg Issues. 2018;15:112-9. doi: 10.1016/j.vhri.2018.03.001.

37. Majidi A, Ghiasvand R, Hadji M, Nahvijou A, Mousavi AS, Pakgohar M, et al. Priority setting for improvement of cervical cancer prevention in Iran. Int J Health Policy Manag. 2016;5(4):225–32. doi: 10.15171/ijhpm.2015.201.