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Cancer risk in different generations of Middle Eastern immigrants to California, 1988–2013

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Abstract

The objective of this study is to compare cancer risk among different generations of Middle Eastern immigrants (ME) and non-Hispanic whites (NHW) in California between 1988 and 2013. We used data from the California Cancer Registry to identify invasive primary incident cancer cases in three population groups: (*i*) first-generation ME immigrants, (*ii*) second- or subsequent-generations ME immigrants, and (*iii*) NHW. Proportional incidence ratio (PIR) was used to compare cancer risk of the 15 selected most common cancers in the 3 population groups taking into consideration time since immigration for first-generation ME immigrants. First generation ME immigrants were more likely to be at increased risk of stomach (PIR= 3.13) and hepatobiliary (PIR=2.27) cancers in females and thyroid (PIR=2.19) and stomach (PIR=2.13) cancers in males in comparison with NHW. Second- or subsequent-generations ME immigrants were at increased risk of thyroid cancer (PIR=1.43 in females and 2.00 in males) in comparison with NHW, and malignant melanoma cancer (PIR=4.53 in females and 4.61 in males) in comparison with first-generation ME immigrants. The risk levels of breast, thyroid and bladder cancers in ME first generation were significantly higher compared to NHW regardless of time spent in the United States suggesting the role of genetic predisposition, and/or cultural characteristics associated with these cancers. The results suggest that differences in cancer risk between ME first-generation immigrants and NHW change in second or subsequent generations, approaching the risk level of NHW and indicating the impact of acculturation in this immigrant population.

Keywords

California Cancer Registry; cancer risk; different generations; Middle Eastern immigrants

Immigrant studies are recognized for their value in examining epidemiological associations in cancer etiology.[1,2] These studies, particularly if population-based, identify the impact of the ethnic, cultural, genetic background and environmental exposures on cancer risk.[3] Three types of immigrant studies have been previously described. The first type compares cancer risk in immigrants with natives from the host country. The second type measures the impact of the environment by studying cancer risk in immigrants compared to people in the countries of origin of the immigrants.[4] The third type evaluates the impact of acculturation, by measuring cancer risk in different generations of immigrants.[5,6] Acculturation is defined

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as changes in immigrant populations' disease risk over time approaching the risk levels of the host country.[7] This can be attributed to differences in Socioeconomic Status (SES), diet, environmental exposures or screening habits in immigrant populations. According to the Center for Immigration Studies, the number of first generation immigrants in the United States (US) is estimated to reach 47.9 million by 2020.[8] Coming from different countries, with different lifestyles, language barriers, and risk factors, first-generation immigrants are very heterogeneous and sometimes require special health care.[9] Middle Eastern immigrants (ME) constitute one of the growing immigrant populations in the US,[8] and particularly in California.[10,11] They come from a wide geographic area extending from Southwest Asia to Northeast Africa. According to the US census, non-Hispanic whites (NHW) refer to all persons from European, Middle Eastern and North African origin.[12] ME populations are distinct in their diet (e.g., Mediterranean diet), genetic background, cultural preferences and health behaviors.[13] Cancer risk is not homogeneous worldwide. International studies have shown that cancer incidence in ME populations living in the Middle East is different from cancer incidence in the US.[14] The overall cancer incidence was reported to be lower in ME first-generation immigrants compared to other NHW.[15–17] Studies examining cancer in immigrants and their descendants have suggested that cancer rates across generations approach the native host country's rates with succeeding generations.[1,18,19] However, very few studies focused on cancer in different generations of ME immigrants in the US and particularly in California.[20,21] Accurate data of the ME population in California are not available through the US census. This population is included in population statistics with NHW, which makes calculating cancer incidence rates for ME immigrants a challenge. Previous studies applied surrogate statistical methods to estimate risk including the proportional incidence ratio (PIR) for cancer comparisons. This method was used to compare cancer risk between ME immigrants and other NHW in the US,[22] and between the different generations of ME immigrants and NHW.[20] These studies were mainly conducted in the Metropolitan Detroit Area of Michigan. In this study, we are using similar methodology to examine possible changes in cancer risk in ME immigrants first and subsequent generations in California.

The main objective of this study is to compare cancer risk among ME first-, second- or subsequent generations' immigrants, and NHW in California (1988–2013), particularly with respect to the 15 most common invasive primary cancers, taking into consideration the length of stay in the US for ME first generation prior to their cancer diagnosis.

MATERIAL AND METHODS

Study population

California is one of the largest and most populated states in the US, with >39 million residents as of July 2015.[23] California Cancer Registry (CCR) is California's statewide population-based cancer surveillance system. CCR monitors incidence and death from cancer among Californians since 1988.[24] It captures detailed information on cancer cases, including patient's demographics (e.g., gender, country of birth and race), cancer characteristics (e.g., age and stage at diagnosis), treatment and follow-up information. Every cancer diagnosis made in California since 1988 is required by law to be reported to CCR. As

a consequence, the CCR completeness rates are high and expand with time.[24] We obtained a deidentified CCR data (1988–2013). This did not require an Institutional Review Board approval.

In 2007, Nasseri used CCR data and developed the Middle Eastern surname list using: (*i*) A Middle Eastern surname file extracted from the Social Security Number Identification Database (NUMIDENT), (*ii*) Enhanced California Death Certificate Master File, (*iii*) Arab Surname List extracted from NUMIDENT, (*iv*) Early California Cancer Registry files and (*v*) Expertly collected surnames.[25] This surname list has a sensitivity of >90% in men and 86% in women. It has been validated and is included as a permanent variable in the CCR dataset, starting from 1988. Three population groups were selected to be examined in this study using CCR. If a patient had a validated Middle Eastern last name and was born in one of the Middle Eastern countries (Afghanistan, Algeria, Armenia, Bahrain, Djibouti, Egypt, Iraq, Iran, Jordan, Lebanon, Libya, Morocco, Pakistan, Palestine, Saudi Arabia, Somalia, Sudan, Syria, Turkey, Tunisia, Yemen and Israel), he/she was considered an ME first-generation immigrant. If the patient had a validated Middle Eastern last name but was born in the US, he/she was considered an ME second or subsequent generations' immigrant. If the patient did not have an ME last name, was born in the US, and was classified as White in CCR, he/she was considered NHW.

Cancer cases and study participants

We have identified invasive cancer cases using CCR data from 1988 to 2013. If a patient has multiple cancers, only the first cancer was included in the analysis. In this study, we decided to analyze the data with a focus on the 15 most common cancers in each of the three population groups (ME first generation, ME second or subsequent generations and NHW), for both genders (Fig. 1). These 15 cancers, representing the cancers with the highest occurrence, were not the same in each of the three population groups. Therefore, our study covered 19 cancer sites in females and 20 in males (Tables 2 and 3) with a total number of 435,215 females and 465,639 males for these selected cancers. In females, 7,971 were first-generation ME immigrants, 2,642 were second- or subsequent-generation ME immigrants and 424,602 were NHW. However, in males, 10,162 were first-generation ME immigrants, 2,182 were second- or subsequent-generation ME and 453,295 were NHW. Other race/ethnic groups were excluded from our study.

Time from immigration to cancer diagnosis

Time from immigration to cancer diagnosis was calculated by using the year of issue of Social Security Number (SSN), existing in CCR, as estimation for the year of immigration. Assuming that legal immigrants receive their SSN directly after their arrival to the US,[21] the year of issue of SSN can be used to estimate the immigration date and therefore the duration of stay in the US. Time since immigration was then categorized into 3 different groups with <10 years, 10–24 years and 25 years over.

Statistical analysis

Descriptive data on demographic characteristics (race/ethnicity, marital status, insurance and SES) and cancer characteristics (age, stage and year at diagnosis) were stratified by gender

and presented for each of the three population groups. Tests for normality were completed for continuous variables. Means±SD were used for continuous variables and numbers (%) for frequency variables. Age-adjusted PIRs were calculated. The PIR is the observed number of ME immigrants' cancer cases divided by the number of ME immigrants' cancer cases expected if the ME immigrant population has the same proportion of cancer as that of the NHW population. In more detail, the proportions of each of the 19 invasive cancers in females and 20 cancers in males were calculated from all cancers in NHW (all cancers include the cancers that are not part of the 19 or 20 cancers) for each of the 18 different 5-year age groups. Then considering that the ME population has the same proportion of cancer as of that of the NHW population, we estimated the expected number of cases for the 19 invasive cancers in females and 20 cancers in males for each age group in first generation ME immigrants. The PIR was calculated using the total of observed cases divided by the total of expected cases for each cancer for first-generation ME, separately in males and females.[26] The comparison of PIR is the NHW group. After calculating the age-adjusted total PIR, 95% Poisson CI was calculated. PIRs >1 indicate that there are proportionally more cancers of a given site among ME first-generation immigrants than among NHW, accounting for differences in the age distribution of the groups. PIRs >1 with 95% CI not containing 1 indicate statistically significant higher proportions. Same analyses were repeated for second- or subsequent-generation ME immigrants compared to NHW and compared to first-generation ME immigrants, separately in males and females. Additional PIRs were calculated for cancers in first-generation ME compared to NHW, stratified by gender and time from immigration to cancer diagnosis. Data analyses were completed using SAS statistical software, version 9.4 (SAS Institute Inc., Cary, NC).

RESULTS

In females, breast cancer constituted the most common cancer with 38.4% in ME first generation, 33.0% in ME second or subsequent generations ME and 30.8% in NHW. Prostate cancer was the most common cancer in males in the 3 groups with 28.7% in ME first generation, 27.4% in ME second or subsequent generations and 27.3% in NHW. In both genders, the second most common cancer in ME first generation was colorectal cancer (CRC); however, it was lung cancer in ME second or subsequent generations and NHW (Fig. 1).

Table 1 shows the demographic and cancer characteristics for participants with the 15 selected most common cancers in each of the 3 population groups and stratified by gender. Overall, 435,215 females and 465,639 males were included. More than 89% of the ME immigrants were identified as NHW. Married and participants with the highest SES accounted for the topmost percentage of cases. Males had higher age at diagnosis compared to females, with NHW having the highest age at diagnosis. Immigrants were diagnosed at later years, whereas NHW were diagnosed mostly between 1988 and 1992. More than 40% of the primary invasive cancers were diagnosed at a localized stage in the 3 groups.

Table 2 presents the age-adjusted PIRs for first-generation and second- or subsequent-generation ME females compared to NHW females. Of the 19 primary invasive female cancers, nine had significantly higher proportions in first generation but only five in second

or subsequent generations' females, four of which were the same in all ME generations. Although the highest PIR was for stomach cancer in all ME immigrant groups, its PIR was lower in second or subsequent generations' females (PIR=1.46). Same pattern was shown for thyroid cancer where the PIR decreased in second or subsequent generations, however, remained significantly higher in comparison with NHW females.

Of the 20 invasive primary cancers, 12 cancers were significantly higher in first generation males and five in second or subsequent generations (Table 3). All generations of ME immigrants had a higher risk of thyroid, bladder and Hodgkin lymphoma cancers with first generation having higher PIRs than second or subsequent generations. First-generation immigrants had a higher risk of stomach (PIR=2.13), liver (PIR=1.43) and leukemia (PIR=1.38) cancers while second or subsequent generations were at higher risk of kidney cancer (PIR=1.27) in comparison with NHW males.

Second or subsequent generations had higher risk of malignant melanoma cancer with a PIR of 4.53 (95% CI: 3.52, 5.73) in females and 4.61 (95% CI: 3.57, 5.87) in males when compared to first generation of ME immigrants. The PIR for lung cancer was the second most highest in females (PIR=2.31) but not in males (PIR=1.20) (Table 4).

Table 5 presents the age-adjusted PIRs for the 5 most common cancers in first generation ME immigrants compared to NHW, stratified by gender and time from immigration to cancer diagnosis. In females, there was an increase in PIR overtime for CRC. Whereas, breast and thyroid cancers maintained significant higher PIRs regardless of the length of time since immigration. In males, the PIR for bladder cancer remained higher regardless of the period since immigration while there was an increase in CRC and non-Hodgkin lymphoma cancer risks.

DISCUSSION

Immigrant studies, using first and subsequent generations, are invaluable in identifying the impact of the ethnic, cultural, genetic predisposition, environmental exposure and gene*environmental interaction on the etiology and distribution of cancer. The overall aim of this study was to compare cancer risk among ME first-, second- or subsequent-generation immigrants, and NHW, for the most common invasive primary cancers, taking into consideration the length of time since immigration to the US for ME first-generation females and males. Our research question focused on the ME population at large and not on individual Middle Eastern countries.

Our results show that the distribution of invasive cancers is very similar in ME first, second or subsequent generations, and NHW, in both males and females. They confirm previous studies looking at cancer in four countries of the Middle East in comparison with the US.[27] Breast cancer is the most common cancer in females in the 3 population groups, similar to many ME countries including Lebanon,[28,29] Iran,[30] Tunisia,[31] Egypt and Gaza strip.[32] Prostate cancer is the most common cancer in males in the 3 groups, similar to some ME countries,[33] but not all.

Several cancer types have significantly higher PIRs in first generation ME compared to NHW. These cancers include stomach, biliary & gallbladder, thyroid, multiple myeloma, leukemia, CRC and bladder cancers in females. They also include stomach, bladder, CRC, non-Hodgkin lymphoma, brain and liver cancers in males. These differences were attenuated in second and subsequent ME generations compared to NHW indicating the impact of possible acculturation due to changes associated with environmental (diet, exposure early in life, …), cultural, other nongenetic causes and gene × environment interaction. The reduction in PIR between first- and second- or subsequent-generation ME immigrants is more pronounced for stomach, larynx, liver, bladder and biliary and gallbladder cancers, where second or subsequent ME immigrants are not exposed to environmental agents such as *Helicobacter pylori* and hepatitis B responsible for the increased risk of stomach and hepatobiliary cancers in first-generation immigrants.

On the other hand, there is an increase in PIRs in second or subsequent generations ME for kidney cancer in males, and for Hodgkin lymphoma in females, in comparison with NHW. Hypotheses regarding availability of screening modalities in the US compared to ME countries and more exposure to kidney cancer associated causes in the US compared to the Middle East can be considered while examining acculturation. Several cancer types have significantly higher PIRs in second or subsequent generations ME immigrants in comparison to first generation. These cancers include malignant melanoma, lung and kidney cancers, where second or subsequent generations are more susceptible to social behaviors such as sunbathing[34] and smoking which explain the differences between the different generations.

To further investigate the effect of acculturation, we examined the change in cancer risk in first-generation ME immigrants compared to NHW, with the length of stay in the US, starting from immigration to cancer diagnosis. Cancers, such as CRC in both genders and non-Hodgkin lymphoma in males, have significantly higher PIRs with more prolonged time since immigration. This unanticipated increase in CRC risk can be explained by: changes in diet particularly the increase in red meat consumption,[35] reduction in physical activity[36] and other gene-environment interaction. Acculturation of ME immigrants and sharing a Westernized lifestyle, particularly replacing their original Mediterranean diet with a Western diet indicates the importance of diet in the etiology of CRC. However, the increase of non-Hodgkin lymphoma overtime in first-generation immigrants can be explained by differences in SES with more time spent in the US and changes in screening modalities and access to health care between the Middle East and the US. Investigating cancer risk overtime can also be helpful in identifying the effect of genetic predisposition on cancer. Cancers, such as breast and thyroid, have significantly higher PIRs in all generations of ME immigrants compared to NHW. The persistence of this relationship with a longer period of stay in the US for ME first-generation female immigrants suggests the role of genetic predisposition on breast[37] and thyroid cancers.[38]

Our results add to the limited literature on Middle Eastern immigrants in the US.[13,20,22] To our information, only one other study looked at cancer risk in different generations of ME immigrants.[20] This study was conducted in California and our results are similar with higher risk of cancers such as stomach and liver in ME first-generation males, bladder in ME second- or subsequent-generation males, stomach and thyroid in ME first-generation

females, and thyroid in ME second- or subsequent-generation females, when compared with NHW.

Literature on ME immigrants in the US is very scarce. Our study adds new insights and contributes to the understanding of acculturation in these ME immigrants to California. To our knowledge, this is the first study to examine cancer risk for the most common cancers in different generations of immigrants from the Middle East to California, with taking the length of stay from immigration to cancer diagnosis into consideration. We included the 2 approaches needed to investigate the role of acculturation on cancer in immigrants[4] by looking at cancer in first generation of ME immigrants stratified by duration of time since immigration to the US in addition to cancer risk in different generations of ME immigrants. This study is one of few to use the year of issue of SSN as an estimate for year of immigration, and therefore calculate the duration of stay in the US from immigration to cancer diagnosis in ME immigrants. We used CCR which is California's statewide population-based cancer registry, with cancer cases diagnosed between 1988 and 2013. In addition, while calculating the PIRs, we adjusted for age to account for cancer differences due to age at diagnosis in the 3 groups.

This study has some limitations. Maiden name is not accessible for Health Insurance Portability and Accountability Act reasons, so we were not able to capture ME females who changed their last name after marriage or children born to ME females but not ME males given that the children usually take the father's last name in the Middle Eastern culture. In addition, we were not able to identify ME immigrants with missing ME last name or missing place of birth. For this study, we used SSN to estimate the length of stay in the US but not age at immigration. This may influence ME cancer risk and we will use it in future studies. We have small sample sizes for some of the cancers limiting the power of our analysis. Last, we do not have available information on diet, smoking habits and body composition. Smoking is the highest risk factor for lung and bladder cancers, with smoking rates varying among the Middle Eastern countries, and between males and females.[27] We expect the dietary patterns to be similar between the Middle Eastern countries. However, immigrants tend to adapt to a more Westernized diet after immigration. Reproductive factors are very important in breast cancer risk and therefore, the availability of these factors may have helped in the interpretation of breast cancer results.

In conclusion, our results suggest differences in cancer risk between ME first-generation immigrants and NHW. However, these differences decline in second or subsequent generations, suggesting the impact of acculturation on cancer risk in second or subsequent generations which approaches the risk level of NHW in the US. The differences between the ME different generations and the possible acculturation which takes place particularly in second or subsequent generations have strong potential for creating and testing causal hypotheses for cancer, which can be tested and increase our knowledge to plan prevention and control of cancer.

Abbreviations:

CCR	California Cancer Registry

CI	confidence interval
CRC	colorectal cancer
SD	standard deviation
ME	Middle Eastern immigrants
N (%)	sample size (percentage)
NHW	non-Hispanic whites
PIR	proportional incidence ratio
SES	socio-economic status
SSN	Social Security Number
US	United States

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What's new?

Middle Eastern immigrants (ME) constitute a growing immigrant population in the United States. However, very few studies have examined cancer risk in this population. In this study, the authors compared cancer risk among different generations of ME immigrants versus non-Hispanic whites (NHW) in California. The differences in cancer risk between ME immigrants and NHW were higher in first-generation immigrants than in second or subsequent generations, approaching the risk level of NHW. These results suggest a possible acculturation impact.

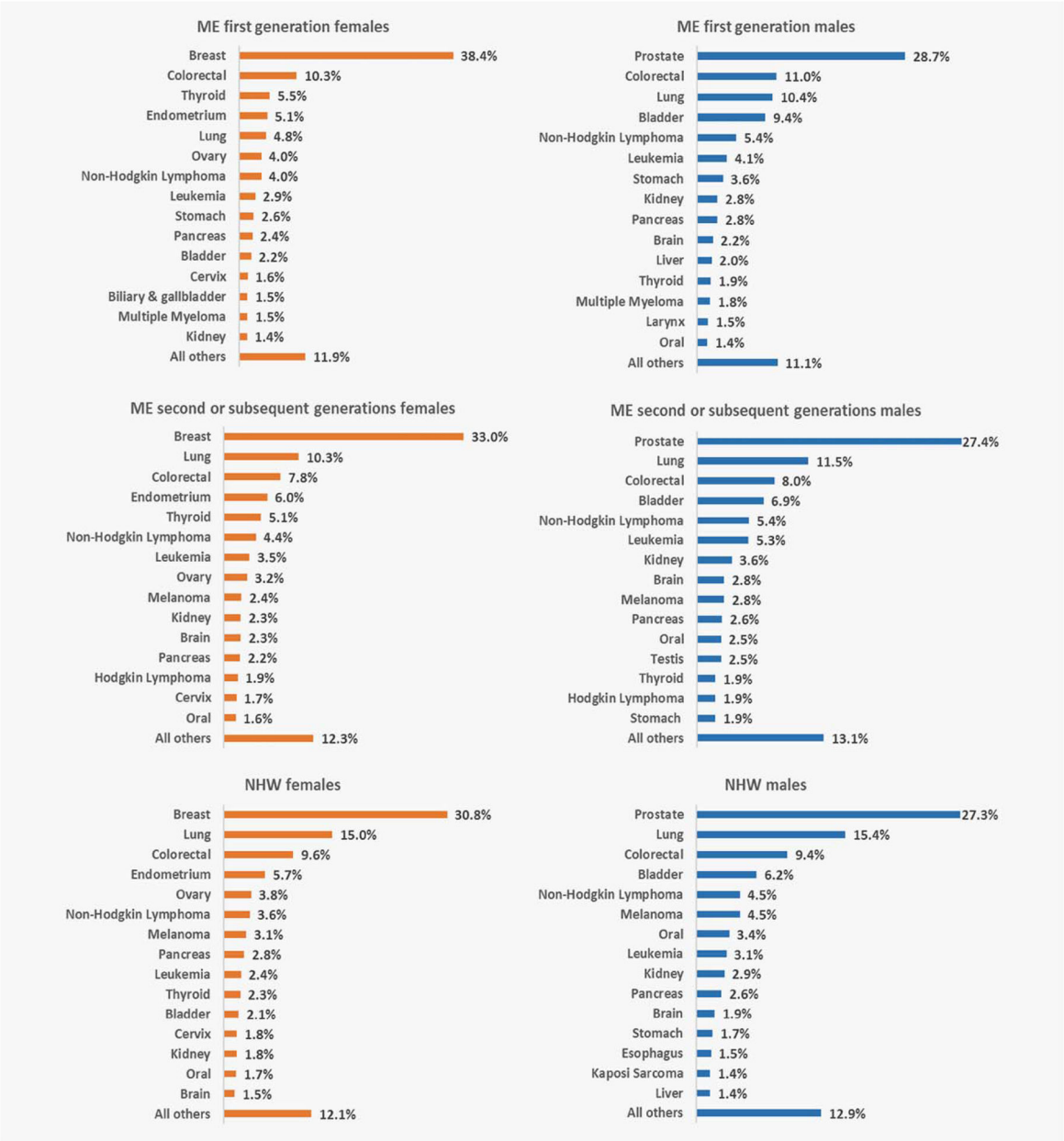

Figure 1.

Invasive primary cancer case distribution for the 3 population groups in both females and males. Abbreviations: ME: Middle Eastern immigrants; NHW: non-Hispanic whites.

Table 1.

Demographic and cancer characteristics of study participants with the selected most common primary invasive cancers: CCR 1988–2013

Characteristics	Females (*N* = 435,215)			Males (N = 465,639)		
	ME first generation, *N* = 7,971	ME second or subsequent generations, *N* = 2,642	NHW, *N* = 424,602	ME first generation, *N* = 10,162	ME second or subsequent generations, *N* = 2,182	NHW, *N* = 453,295
Demographics						
Race/ethnicity. N (%)						
Identified as NHW	7,316 (91.8)	2,364 (89.5)	424,602 (100)	9,422 (92.7)	1,950 (89.4)	453,295 (100)
Identified as other race/ ethnicity	655 (8.2)	278 (10.5)	0	740 (7.3)	232 (10.6)	0
Marital status. N (%)						
Single	798 (10.0)	518 (19.6)	50,863 (12.0)	925 (9.1)	475 (21.8)	63,299 (14.0)
Married	4,539 (57.0)	1,313 (49.7)	202,524 (47.7)	7,961 (78.3)	1,345 (61.6)	304,221 (67.1)
Separated/divorced	521 (6.5)	304 (11.5)	53,495 (12.6)	496 (4.9)	176 (8.1)	36,375 (8.0)
Widowed	1,945 (24.4)	461 (17.5)	109,379 (25.7)	498 (4.9)	140 (6.4)	37,525 (8.3)
Unknown	168 (2.1)	46 (1.7)	8,341 (2.0)	282 (2.8)	46 (2.1)	11,875 (2.7)
Insurance. N (%)						
Managed care, HMO, PPO, Private	2,368 (29.7)	1,132 (42.9)	141,585 (33.4)	2,757 (27.1)	812 (37.2)	141,155 (31.1)
Medicaid	1,513 (19.0)	135 (5.1)	14,067 (3.3)	1,435 (14.1)	108 (5.0)	13,076 (2.9)
Medicare	2,268 (28.5)	559 (21.2)	97,983 (23.1)	3,499 (34.4)	563 (25.8)	110,034 (24.3)
Insured, other type	262 (3.3)	138 (5.2)	19,574 (4.6)	280 (2.8)	79 (3.6)	19,030 (4.2)
Not insured/unknown	1,560 (19.5)	678 (25.6)	151,393 (35.6)	2,191 (21.6)	620 (28.4)	170,000 (37.5)
SES. N (%)						
Lowest SES	554 (6.9)	261 (9.9)	44,977 (10.6)	829 (8.1)	239 (10.9)	47,970 (10.6)
Lower-middle SES	1,187 (14.9)	374 (14.1)	78,619 (18.5)	1,510 (14.9)	326 (14.9)	83,252 (18.4)
Middle SES	1,559 (19.6)	457 (17.3)	94,339 (22.2)	1,835 (18.1)	396 (18.2)	98,482 (21.7)
Higher-middle SES	1,904 (23.9)	636 (24.1)	100,920 (23.8)	2,336 (23.0)	516 (23.7)	106,391 (23.5)
Highest SES	2,767 (34.7)	914 (34.6)	105,747 (24.9)	3,652 (35.9)	705 (32.3)	117,200 (25.8)
Cancer Characteristics						
Age at diagnosis.						
Mean (SD)	61.0 (15.2)	58.1 (18.9)	64.9 (15.5)	65.1 (13.4)	61.0 (19.2)	65.6 (14.2)
Median	62	61	67	66	66	67

Characteristics	Females (*N* = 435,215)			Males (N = 465,639)		
	ME first generation, *N* = 7,971	**ME second or subsequent generations, *N* = 2,642**	**NHW, *N* = 424,602**	**ME first generation, *N* = 10,162**	**ME second or subsequent generations, *N* = 2,182**	**NHW, *N* = 453,295**
Year at diagnosis. N (%)						
1988–1992	903 (11.3)	422 (16.0)	99,351 (23.4)	1,187 (11.7)	401 (18.4)	116,543 (25.7)
1993–1997	1,293 (16.2)	450 (17.0)	90,466 (21.3)	1,824 (18.0)	408 (18.7)	98,407 (21.7)
1998–2002	1,732 (21.7)	509 (19.3)	85,038 (20.0)	2,206 (21.7)	417 (19.1)	85,404 (18.9)
2003–2007	1,766 (22.2)	576 (21.8)	73,550 (17.3)	2,339 (23.0)	449 (20.6)	76,773 (16.9)
2008–2013	2,277 (28.6)	685 (25.9)	76,197 (18.0)	2,606 (25.6)	507 (23.2)	76,168 (16.8)
Stage at diagnosis. N (%)						
In situ	71 (0.9)	18 (0.7)	2,618 (0.6)	387 (3.8)	50 (2.3)	8,695 (1.9)
Localized	3,468 (43.5)	1,146 (43.4)	178,161 (42.0)	4,546 (44.7)	1,003 (46.0)	194,135 (42.8)
Regional	2,389 (30.0)	719 (27.2)	106,947 (25.2)	2,042 (20.1)	395 (18.1)	88,665 (19.6)
Remote	1,711 (21.4)	647 (24.5)	103,526 (24.4)	2,571 (25.3)	586 (26.8)	118,393 (26.1)
Unknown	332 (4.2)	112 (4.2)	33,350 (7.8)	616 (6.1)	148 (6.8)	43,407 (9.6)

Abbreviations: CCR: California Cancer Registry; ME: Middle Eastern immigrants; NHW: non-Hispanic whites; N (%): sample size (percentage); SES: socioeconomic status; SD: standard deviation.

Table 2.

Age-adjusted PIRs (95% CI) for different generations of ME female immigrants compared to NHW females for the most common 19 primary invasive cancers: CCR 1988–2013

Cancer type	ME first generation				ME second or subsequent generations			
	Total observed	Total expected	PIR	95% CI	Total observed	Total expected	PIR	95% CI
Breast	3,331	2,856.80	1.17[1]	1.13, 1.21	948	877.91	1.08[1]	1.01, 1.15
Colorectal	892	745.01	1.20[1]	1.12, 1.28	225	231.03	0.97	0.85, 1.11
Thyroid	480	253.03	1.90[1]	1.73, 2.07	145	101.55	1.43[1]	1.20, 1.68
Endometrium	442	498.15	0.89	0.81, 0.97	172	151.19	1.14	0.97, 1.32
Lung	416	1,211.10	0.34	0.31, 0.38	296	370.25	0.80	0.71, 0.90
Ovary	347	333.77	1.04	0.93, 1.16	93	108.81	0.85	0.69, 1.05
Non-Hodgkin lymphoma	346	303.54	1.14[1]	1.02, 1.27	127	101.39	1.25[1]	1.04, 1.49
Leukemia	250	184.31	1.36[1]	1.19, 1.54	101	96.88	1.04	0.85, 1.27
Stomach	227	72.34	3.13[1]	2.74, 3.57	33	22.59	1.46[1]	1.01, 2.05
Pancreas	208	214.98	0.97	0.84, 1.11	62	66.57	0.93	0.71, 1.19
Bladder	190	161.72	1.17[1]	1.01, 1.35	41	50.24	0.82	0.59, 1.11
Cervix uteri	138	195.21	0.71	0.59, 0.84	49	67.59	0.72	0.54, 0.96
Biliary and gall bladder	129	56.75	2.27[1]	1.90, 2.70	19	17.46	1.09	0.65, 1.70
Multiple myeloma	127	83.36	1.52[1]	1.27, 1.81	30	25.55	1.17	0.79, 1.68
Kidney	122	146.84	0.83	0.69, 0.99	66	53.14	1.24	0.96, 1.58
Brain	115	131.88	0.87	0.72, 1.05	65	70.01	0.93	0.72, 1.18
Oral	98	142.91	0.69	0.56, 0.84	46	46.10	1.00	0.73, 1.33
Hodgkin lymphoma	68	61.17	1.11	0.86, 1.41	55	38.80	1.42[1]	1.07, 1.85
Melanoma	45	313.18	0.14	0.10, 0.19	69	113.29	0.61	0.47, 0.77

Abbreviations: PIRs: proportional incidence ratios; CI: confidence interval; ME: Middle Eastern immigrants; NHW: non-Hispanic whites; CCR: California Cancer Registry.

[1]Significant higher PIRs.

Table 3.

Age-adjusted PIRs (95% CI) for different generations of ME male immigrants compared to NHW males for the most common 20 primary invasive cancers: CCR 1988–2013

	ME first generation				ME second or subsequent generations			
Cancer type	**Total observed**	**Total expected**	**PIR**	**95% CI**	**Total observed**	**Total expected**	**PIR**	**95% CI**
Prostate	3,149	2,998.80	1.05[1]	1.01, 1.09	650	587.68	1.11[1]	1.02, 1.19
Colorectal	1,208	1,031.30	1.17[1]	1.11, 1.24	190	205.21	0.93	0.80, 1.07
Lung	1,143	1,694.40	0.67	0.64, 0.71	272	333.45	0.82	0.72, 0.92
Bladder	1,034	671.02	1.54[1]	1.45, 1.64	164	133.54	1.23[1]	1.05, 1.43
Non-Hodgkin lymphoma	589	498.79	1.18[1]	1.09, 1.28	127	116.13	1.09	0.91, 1.30
Leukemia	453	327.30	1.38[1]	1.26, 1.52	126	105.48	1.19	1.00, 1.42
Stomach	399	187.24	2.13[1]	1.93, 2.35	44	37.20	1.18	0.86, 1.59
Pancreas	308	279.60	1.10	0.98, 1.23	61	55.28	1.10	0.84, 1.42
Kidney	310	321.57	0.96	0.86, 1.08	86	67.94	1.27[1]	1.01, 1.56
Brain	238	204.74	1.16[1]	1.02, 1.32	67	69.34	0.97	0.75, 1.23
Testis	91	142.53	0.64	0.51, 0.78	59	55.71	1.06	0.81, 1.37
Melanoma	68	503.97	0.13	0.10, 0.17	66	109.94	0.60	0.46, 0.76
Oral	157	380.75	0.41	0.35, 0.48	59	76.80	0.77	0.58, 0.99
Liver	217	151.63	1.43[1]	1.25, 1.63	31	31.93	0.97	0.66, 1.38
Multiple myeloma	202	137.70	1.47[1]	1.27, 1.68	36	27.13	1.33	0.93, 1.84
Thyroid	206	94.26	2.19[1]	1.90, 2.51	46	22.95	2.00[1]	1.47, 2.67
Larynx	163	134.50	1.21[1]	1.03, 1.41	18	26.33	0.68	0.41, 1.08
Hodgkin lymphoma	112	70.99	1.58[1]	1.30, 1.90	45	29.88	1.51[1]	1.10, 2.02
Esophagus	56	163.48	0.34	0.26, 0.44	14	31.94	0.44	0.24, 0.74
Kaposi sarcoma	59	165.14	0.36	0.27, 0.46	21	43.05	0.49	0.30, 0.75

Abbreviations: PIRs: proportional incidence ratios; CI: confidence interval; ME: Middle Eastern immigrants; NHW: non-Hispanic whites; CCR: California Cancer Registry.

[1]Significant higher PIRs.

Table 4.

Age-adjusted PIRs (95% CI) for ME second- or subsequent-generation immigrants compared to ME first-generation immigrants for the selected most common primary invasive cancers, stratified by gender: CCR 1988–2013

Cancer type	Total observed	Total expected	PIR	95% CI
Females				
Breast	948	1,024.10	0.93	0.87, 0.99
Lung	296	127.97	2.31[1]	2.06, 2.59
Colorectal	225	275.70	0.82	0.71, 0.93
Endometrium	172	134.52	1.28[1]	1.09, 1.48
Thyroid	145	180.08	0.81	0.68, 0.95
Non-Hodgkin lymphoma	127	117.66	1.08	0.90, 1.28
Leukemia	101	144.68	0.70	0.57, 0.85
Ovary	93	108.73	0.86	0.69, 1.05
Melanoma	69	15.24	4.53[1]	3.52, 5.73
Kidney	66	39.07	1.69[1]	1.31, 2.15
Brain	65	41.07	1.58[1]	1.22, 2.02
Pancreas	62	64.06	0.97	0.74, 1.24
Hodgkin lymphoma	55	39.69	1.39[1]	1.04, 1.80
Cervix uteri	49	44.54	1.10	0.81, 1.45
Oral	46	38.62	1.19	0.87, 1.59
Bladder	41	59.05	0.69	0.50, 0.94
Stomach	33	70.68	0.47	0.32, 0.66
Multiple myeloma	30	38.73	0.77	0.52, 1.11
Biliary and gallbladder	19	39.70	0.48	0.29, 0.75
Males				
Prostate	650	615.66	1.06	0.98, 1.14
Lung	272	226.70	1.20[1]	1.06, 1.35
Colorectal	190	242.90	0.78	0.67, 0.90
Bladder	164	205.86	0.80	0.68, 0.93

Cancer type	Total observed	Total expected	PIR	95% CI
Non-Hodgkin lymphoma	127	131.51	0.97	0.81, 1.15
Leukemia	126	142.66	0.88	0.74, 1.05
Kidney	86	62.91	1.37[1]	1.09, 1.69
Brain	67	70.08	0.96	0.74, 1.21
Melanoma	66	14.30	4.61[1]	3.57, 5.87
Pancreas	61	61.10	1.00	0.76, 1.28
Testis	59	34.21	1.72[1]	1.31, 2.22
Oral	59	32.03	1.84[1]	1.40, 2.38
Thyroid	46	48.07	0.96	0.70, 1.28
Hodgkin lymphoma	45	45.95	1.00	0.71, 1.31
Stomach	44	79.25	0.56	0.40, 0.75
Multiple myeloma	36	40.09	0.90	0.63, 1.24
Liver	31	42.24	0.73	0.50, 1.04
Kaposi sarcoma	21	12.61	1.67[1]	1.03, 2.55
Larynx	18	31.83	0.57	0.34, 0.89
Esophagus	14	11.06	1.27	0.69, 2.12

Abbreviations: PIRs: proportional incidence ratios; CI: confidence interval; ME: Middle Eastern immigrants; CCR: California Cancer Registry.

[1]Significant higher PIRs.

Table 5.

Age-adjusted PIRs (95% CI) for the 5 most common cancers in ME first-generation immigrants compared to NHW, stratified by gender and time from immigration to cancer diagnosis: CCR 1988–2013

Cancer type	Time from immigration to diagnosis[1]	Total observed	Total expected	PIR	95% CI
Females					
Breast	<10	766	605.73	1.26[2]	1.18, 1.36
	10–24	1,643	1,307.70	1.26[2]	1.20, 1.32
	≥25	922	772.63	1.19[2]	1.12, 1.27
Colorectal	<10	188	175.01	1.07	0.93, 1.24
	10–24	437	437.56	1.00	0.91, 1.10
	≥25	267	219.21	1.22[2]	1.08, 1.37
Thyroid	<10	132	61.13	2.16[2]	1.81, 2.56
	10–24	219	119.38	1.83[2]	1.60, 2.09
	≥25	129	48.58	2.66[2]	2.22, 3.15
Endometrium	<10	83	131.26	0.63	0.50, 0.78
	10–24	218	238.32	0.91	0.80, 1.04
	≥25	141	143.14	0.99	0.83, 1.16
Lung	<10	96	308.56	0.31	0.25, 0.38
	10–24	196	528.32	0.37	0.32, 0.43
	≥25	124	356.05	0.35	0.29, 0.42
Males					
Prostate	<10	691	598.32	1.15[2]	1.07, 1.24
	10–24	1,239	1,170.10	1.06	1.00, 1.12
	≥25	1,219	1,133.70	1.08[2]	1.02, 1.14
Colorectal	<10	209	218.83	0.96	0.83, 1.09
	10–24	526	456.28	1.15[2]	1.06, 1.26
	≥25	473	375.97	1.26[2]	1.15, 1.38
Lung	<10	259	453.83	0.57	0.50, 0.64

Cancer type	Time from immigration to diagnosis[1]	Total observed	Total expected	PIR	95% CI
	10–24	505	645.48	0.78	0.72, 0.85
	≥25	379	630.27	0.60	0.54, 0.67
Bladder	<10	222	144.04	1.54[2]	1.35, 1.76
	10–24	434	313.32	1.39[2]	1.26, 1.52
	≥25	378	244.37	1.55[2]	1.39, 1.71
Non-Hodgkin lymphoma	<10	108	111.73	0.97	0.79, 1.17
	10–24	250	236.56	1.06	0.93, 1.20
	≥25	231	161.64	1.43[2]	1.25, 1.63

Abbreviations: PIRs: proportional incidence ratios; CI: confidence interval; ME: Middle Eastern immigrants; NHW: non-Hispanic whites; CCR: California Cancer Registry.

[1]Time from immigration to cancer diagnosis in years.

[2]Significant higher PIRs.