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Cancer incidence among Asian American populations in the United States, 2009-2011

Hongbin Jin[1], **Paulo S. Pinheiro**[1], **Jianbo Xu**[2], and **Amei Amei**[2]

[1]Epidemiology and Biostatistics, Department of Environmental and Occupational Health, School of Community Health Sciences, University of Nevada, Las Vegas

[2]Department of Mathematical Sciences, University of Nevada, Las Vegas

Abstract

Cancer incidence disparities exist among specific Asian American populations. However, the existing reports exclude data from large metropoles like Chicago, Houston, and New York. Moreover, incidence rates by subgroup have been underestimated due to the exclusion of Asians with unknown subgroup. Cancer incidence data for 2009 to 2011 for eight states accounting for 68% of the Asian American population were analyzed. Race for cases with unknown subgroup was imputed using stratified proportion models by sex, age, cancer site, and geographic regions. Age-standardized incidence rates were calculated for 17 cancer sites for the six largest Asian subgroups. Our analysis comprised 90,709 Asian and 1,327,727 non-Hispanic white cancer cases. Asian Americans had significantly lower overall cancer incidence rates than non-Hispanic whites (336.5 per 100,000 and 541.9 for men, 299.6 and 449.3 for women, respectively). Among specific Asian subgroups, Filipino men (377.4) and Japanese women (342.7) had the highest overall incidence rates while South Asian men (297.7) and Korean women (275.9) had the lowest. In comparison to non-Hispanic whites and other Asian subgroups, significantly higher risks were observed for colorectal cancer among Japanese, stomach cancer among Koreans, nasopharyngeal cancer among Chinese, thyroid cancer among Filipinos, and liver cancer among Vietnamese. South Asians had remarkably low lung cancer risk. Overall, Asian Americans have a lower cancer risk than non-Hispanic whites, except for nasopharyngeal, liver and stomach cancers. The unique portrayal of cancer incidence patterns among specific Asian subgroups in this study provides a new baseline for future cancer surveillance research and health policy.

Corresponding author: Hongbin Jin, School of Community Health Sciences, University of Nevada, Las Vegas, Box 453063, 4505 S. Maryland Parkway, Las Vegas, NV 89154-3063, Phone: (702) 750-7972, Fax: (702) 895-3064, hongbin.jin@unlv.edu.

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Illinois Department of Public Health, Illinois State Cancer Registry is the source of Illinois cancer incidence data. The conclusions, opinions, and recommendations expressed in this article are not necessarily the conclusions, opinions, or recommendations of the Department.
Texas cancer incidence data have been provided by the Texas Cancer Registry, Cancer Epidemiology and Surveillance Branch, Texas Department of State Health Services, PO Box 149347, Austin, Texas, 78756.
Washington State Department of Health is the source of non-SEER Washington cancer incidence data. The authors are the source of interpretations, calculations or manipulations of the data.

Keywords

Cancer; incidence; Asian American; disparities; epidemiology

Introduction

Asian Americans are the fastest growing racial/ethnic group in the United States (US)[1]. Between 2000 and 2010, the Asian American population grew by 43%, from 10.2 million to 14.7 million, which was more than four times faster than growth in the total US population[1]. This has been fueled primarily by international immigration from Asia[2]. In 2010, 74% of Asian American adults were foreign-born; of those, 36% immigrated in 2000 or later[3,4]. The most populous Asian subgroup was Chinese, with 4 million people, followed by Filipino and Asian Indian with 3.4 million and 3.2 million people, respectively[1]. The heterogeneous Asian American population is comprised of distinct subgroups with differences in genetics, culture, lifestyle, immigration and settlement experiences[5]. This diversity must be explored to better understand disparities in cancer incidence among Asian subgroups and to identify protective attributes as well as risk factors that can shape cancer intervention strategies.

Most cancer research aggregates Asian Americans into one single group, potentially blurring important differences among specific Asian subgroups[5]. Some previous studies using population-based cancer registry data have revealed clear differences in cancer incidence among specific Asian subgroups[6-15]. However, these studies have a few limitations. Firstly, all reported national rates were based solely on data from the Surveillance, Epidemiology, and End Results (SEER) Program, whose catchment area excludes some major metropolitan areas with large Asian American populations, such as New York, Houston, and Chicago. These areas are only covered by the National Program of Cancer Registries (NPCR). Secondly, Asian cancer cases in SEER with missing Asian subgroup category were classified as not-otherwise-specified (NOS) and routinely excluded from incidence analyses, leading to underestimated rates by subgroup. Also, without accurately accounting for these NOS cases, which represented up to 13% of all Asians in 2008-2012 SEER data, comparisons among the Asian subgroups as well as between these and the other US racial groups are possibly biased. The final significant limitation of previous studies is the use of inflated population estimates due to the inclusion of multiracial Asians in total Asian population. While bridging methods have been widely used to compute population estimates for specific Asian subgroups[6-15], these methods include multiracial Asians in combination with non-Asian race(s) (e.g., Black), thus giving rise to misclassification in population estimates and possible mismatches between numerators and denominators.

In this study, we directly address these limitations by (1) including cancer data from all major states with large Asian populations, (2) imputing NOS cases, and (3) using population estimates bridged between single Asian race and Asian in combination with other Asian race(s). Using 2009-2011 data, we estimate cancer incidence rates for each of the six largest Asian subgroups in the US: Chinese, Filipino, Japanese, Korean, South Asian, and Vietnamese for 17 most common cancer sites.

Materials and Methods

Study Data

Cancer incidence data (2015 submission) on the 3-year period from January 1, 2009 through December 31, 2011 were obtained from the eight US states with the largest population concentration of Asian Americans: California, Florida, Hawaii, Illinois, New Jersey, New York, Texas, and Washington state, accounted for 68% of the total Asian American population (10 million out of the 14.7 million total) in the US (Table 1).

All cases of malignant cancers, in addition to *in situ* urinary bladder cancers were included. Seventeen most common cancer sites were classified as follows: oral cavity and pharynx, stomach, colon and rectum, liver and intrahepatic bile duct, pancreas, lung and bronchus, breast, cervix uteri, corpus uteri, ovary, prostate, urinary bladder, kidney and renal pelvis, thyroid, non-Hodgkin's lymphoma, leukemia, and all-other-sites combined. Due to the known high risk for nasopharynx cancer among Asians, we also looked at this subcategory within oral cavity and pharynx separately[8]. Female breast cancer was further stratified using a cutoff age of 50 into premenopausal and postmenopausal categories because they have different underlying risk factors which may vary by Asian subgroup. Cancer site was coded according to the International Classification of Diseases for Oncology, Third Edition (ICD-O-3).

The North American Association of Central Cancer Registries (NAACCR) Standards for Cancer Registries code Asian race in 12 different subgroups, including Asian Indian, Chinese, Filipino, Hmong, Japanese, Kampuchean, Korean, Laotian, Pakistani, Thai, Vietnamese, and NOS[16]. Unfortunately, other Asian subgroups, e.g. Malaysians, Indonesians, etc. are not identified by a race descriptor and are therefore commonly classified as NOS, lumped together with cases of the 11 racial subgroups described above for whom a specific subgroup is missing. In our study, these cases for which there is no race descriptor were aggregated into a single category called Other Specified Asian (OSA).

All Asian cases were included regardless of Hispanic ethnicity. Race 1 and Race 2 (NAACCR items 160 and 161) were used as the Asian race indicator[16]. Asians cases reporting non-Asian race(s) except white were excluded because Asian only takes precedence over white in multiracial coding[17]. Asian Indian and Pakistani were aggregated into one single category, South Asian, according to NAACCR coding protocol. Although too small to be included in the aims of this study, smaller Hmong, Kampuchean, Laotian, and Thai populations were aggregated into one Southeast Asian category in order to account for them in the NOS pool. US non-Hispanic whites were used as the referent group.

NOS cases were reassigned by imputation models stratified by age, sex, cancer site, and geographic region. We identified 12 geographic regions, one for each state except California, which was divided into five regions due to its large Asian American population and an uneven distribution of specific Asian subgroups (Table 1). We considered the boundary of the local cancer registries, the proportions of different Asian subgroups and geographical adjacency to derive these 5 California regions: Los Angeles County, Bay Area Region (including Alameda, Contra Costa, Marin, San Francisco and San Mateo Counties), Santa

Clara Region (including Monterey, San Benito, Santa Clara and Santa Cruz Counties), Greater California without Orange County, and Orange County. The latter was carved out from Greater California due to a substantially higher proportion of Vietnamese than other California regions.

To take into account the NOS cases in our incident counts we proceeded as follows. Birthplace was used to enhance the identification of the 11 specified Asian subgroups as well as identify OSA (e.g., a NOS case with a birthplace of China was recoded as Chinese; a NOS case with a birthplace of Malaysia was recoded as OSA). In order to estimate the quantity of OSAs that could not be identified by birthplace but would have been identified by a race specific descriptor had it existed in the NAACCR standards, we used an average ratio between those with a specific race without a matching birthplace and those of the same race but with a matching birthplace (e.g. Filipino race, birthplace Philippines) among Filipinos, Koreans, Southeast Asians, and Vietnamese. The choice of these four subgroups was based on the similar history of more recent immigration to the US to those of OSAs, such as Indonesia and Malaysia. The remaining NOS cases were reassigned by stratified imputation models as performed in previous research on cancer risk[18].

Variables are defined as follows: age group j=1-5 for ages 0-19, 20-44, 45-59, 60-74, ≥75; cancer site l=1-17 for oral cavity and pharynx, stomach,…, other-site combined; geographic region m=1-12 for Los Angeles County, …, Florida; Asian subgroup i=1 for South Asian, 2 for Chinese, 3 for Japanese, 4 for Filipino, 5 for Korean, 6 for Vietnamese, 7 for Southeast Asian, 8 for OSA, and 9 for NOS. D is the number of cases whose race matches birthplace, and d is the number of cases whose race does not match birthplace.

For each age group j, cancer site l, and geographic region m, we defined the total (N) of a specific Asian subgroup i as:

$$N_{ijlm}=D_{ijlm}+d_{ijlm}$$

Hence, the average ratio (AR) was:

$$AR_{jlm}=(\sum_{i=4}^{7} d_{ijlm}/D_{ijlm})/4$$

The estimate for OSAs that cannot be identified by birthplace and the total number of OSAs was given by:

$$d_{8jlm}=D_{8jlm}AR_{jlm}$$

$$N_{8jlm}=D_{8jlm}+d_{8jlm}$$

We then defined the proportion (P) of each Asian subgroup i over total Asians as:

$$P_{ijlm}=N_{ijlm}/(\sum_{i=1}^{7}N_{ijlm}+N_{8jlm})$$

Given the uneven distribution of NOS cases by age, 18 age groups (k=1-18 for ages 0-4, 5-9, …, 80-84, ≥85) were used for proportionate partition. The average ratios and proportions based on j were used for k when the corresponding age groups indexed by k overlap with those groups indexed by j (e.g., j=1 when k=1-4). Hence, adjusted total (N^*) of NOS cases was given by:

$$N^*_{9klm}=N_{9klm}-D_{8klm}AR_{jlm}$$

Adjusted total of NOS cases were proportionately partitioned to each Asian subgroup as follows:

$$N^*_{iklm}=N_{iklm}+N^*_{9klm}P_{ijlm}$$

Population data were derived from 2010 US Census. Since Asians that report several Asian subgroups are counted several times in census counts, the sum of all specific Asian subgroups exceeds the total Asian population[1]. To adjust this, we applied sex and age-specific proportions of multiple-Asian-race counts for each subgroup to the net difference between the real total and single-Asian-race counts to derive subgroup estimates.

Average annual cancer incidence rates per 100,000 persons were calculated with and without stratified imputation for comparison, and age-standardized to the 2000 US Standard Population. Corresponding 95% confidence intervals (CIs) were calculated with gamma intervals modification[19]. R 3.13 and SAS 9.3 were used for data analysis.

This study was approved by the University of Nevada, Las Vegas Institutional Review Board (IRB), the Illinois Department of Public Health IRB, and the Washington State IRB. Data use agreements were obtained from the SEER program, the New York Cancer Registry, the Texas Cancer Registry, the Illinois State Cancer Registry, the Washington State Cancer Registry, and the Florida Cancer Data System.

Results

A total of 90,709 Asian and 1,327,727 non-Hispanic white new cancer cases were diagnosed from 2009 to 2011 in the eight states in our study (Table 2). California accounted for 52% of all the Asian cases, followed by New York with 10%. Of Asian cancer cases, 15% were NOS (12% in SEER and 23% in NPCR). Due to the uneven distribution of NOS cases, the increase in overall incidence rates after stratified imputation varied considerably by Asian subgroup with the lowest increment of 8% observed in Japanese men and the highest of 25% in South Asian women (Table 3 and 4; Supporting Information Table 1 and 2). Within each Asian subgroup, the increment also differed substantially by cancer site. The overall cancer incidence rate for Asian American men was 336.5/100,000 person-years; for women it was

299.6/100,000. This was nearly 38% and 33% lower than non-Hispanic white men and women, respectively. For the majority of cancer sites, incidence rates were lower among all Asian American populations than non-Hispanic whites. However, compared to non-Hispanic whites, Asian Americans had significantly higher rates for three infection-related cancers – nasopharyngeal, liver, and stomach cancers.

Among the Asian subgroups, Filipinos ranked highest in overall cancer incidence for men and second for women, partially due to high prostate and breast cancer rates. They also had the highest thyroid cancer rates (9.7/100,000 in men and 28.5/100,000 in women). Also with high prostate and breast cancer rates, Japanese ranked second in men and first in women for overall cancer incidence. Additionally, colorectal cancer rates were highest in this group (59.5/100,000 in men and 40.5/100,000 in women). The lowest overall cancer incidence rates were found in South Asian men and Korean women, while Chinese men and women had the second lowest overall rates. Remarkably, the Chinese subgroup had the highest nasopharyngeal cancer rates (8.0/100,000 in men and 2.5/100,000 in women) and the Koreans had the highest stomach cancer rates (37.8/100,000 in men and 18.8/100,000 in women), significantly higher than any other Asian populations. Unlike other subgroups, South Asians had low nasopharyngeal, stomach, and liver cancer rates, similar to those of non-Hispanic whites. Notably, they also showed markedly low colorectal (28.1/100,000 in men and 22.3/100,000 in women) and lung cancer rates (27.1/100,000 in men and 14.9/100,000 in women). The Vietnamese subgroup had the highest liver cancer rates (52.8/100,000 in men and 15.5/100,000 in women) as well as the highest cervical cancer rate (9.0/100,000) among Asian subgroups.

Discussion

Our study found that Asian Americans have lower overall cancer incidence rates than non-Hispanic whites, especially for the four most common cancers: prostate, breast, colorectal, and lung. However, in comparison to non-Hispanic whites, Asian Americans are disproportionately affected by infection-related cancers, such as nasopharynx, liver and stomach cancers, but notably not cervical cancer. These findings are consistent with previous research[7-9], although our updated data and new methodology reveal some new cancer patterns among specific Asian subgroups.

The three highest cancer rates in Asian Americans are prostate, lung and colorectal in men, and breast, colorectal and lung in women. There is considerable variation across Asian subgroups but overall risk for these four cancers is lower than in non-Hispanic whites.

Specific cancer differences

Prostate cancer rates were highest among Filipino and Japanese men, but still 19% and 31% lower than rates of non-Hispanic whites. Vietnamese and Korean subgroups showed the lowest risk of prostate cancer among all Asians. Few risk factors are known for prostate cancer except for age and African ancestry. Asian populations traditionally show low risk for this cancer[7-9] but in Western countries like the US incidence is mostly driven by the extent of prostate-specific antigen (PSA) screening coverage[20], which is currently not recommended on a population basis. In clear relation with their incidence rates, it is not

surprising that Filipino and Japanese men have been found to have the highest PSA screening rates (48% and 50%, respectively) while Vietnamese and Korean men have the lowest (13% and 22%) among all Asian subgroups in the California Health Interview Survey[21]. In the literature, the high incidence of prostate cancer for Filipinos among Asian subgroups has been related to their lower consumption of non-fermented soy products[22]. These products are popular in traditional Asian diets and have been associated with a 25%-30% reduced risk for prostate cancer[23,24].

Breast cancer was the leading cancer among women for all Asian subgroups, with Japanese women having a risk comparable to that of non-Hispanic white women, mostly attributable to a significantly higher rate among premenopausal Japanese women. Unlike other Asian subgroups, two-thirds of the Japanese American population is US-born[3]. Previous studies have shown that the cancer rates in US-born Asians approach that of non-Hispanic whites in successive generations and that US-born Asians have distinct profiles from their foreign-born counterparts[13-15]. The excess breast cancer burden in Japanese Americans may also be partially attributed to higher mammogram usage, older age at first childbirth, and lower number of childbirths compared to other Asian subgroups[21], which are prevalent risk factors for breast cancer in Western populations[25,26]. Premenopausal breast cancer has unique protective factors such as weight status and breastfeeding. Further research is needed to explain the higher breast cancer risk in premenopausal Japanese women.

Colorectal cancer rates were relatively high only among the Japanese subgroup, 25% and 11% higher than those of non-Hispanic white men and women. This group also has been found to have the highest colorectal cancer screening rate (83%) among Asian subgroups[21]. Because screening is known to reduce colorectal cancer incidence, our findings suggest that environmental factors are strong drivers of the colorectal cancer risk in this group. As the only subgroup that is majority US-born[3], the Japanese are more likely to have adopted a Western lifestyle, including dietary habits and consequent obesity, which is associated with increased risk for colorectal cancer[21,27]. Similarly, in Japan, an increase in dietary intake of milk, meat, eggs, and fat from 1950 to 1970 has been met with a concomitant sharp rise in colorectal cancer since the early 1990s[28]. In most Asian countries, rapid economic growth resulted in a shift from traditional dietary patterns to an increased intake of fat, sugar and animal-source foods which leads to greater risk of colorectal cancer. Lung cancer rates were highest among the Vietnamese subgroup, but still 11% and 47% lower than those of non-Hispanic white men and women, respectively. Lung cancer rates are predominantly a reflection of past smoking trends, and smoking prevalence is relatively low among Asian Americans, particularly women. According to the California Health Interview Survey[21], Vietnamese in California currently have the highest smoking rates among all Asian subgroups while South Asians have the lowest. This coincides with our findings of higher rates for Vietnamese and remarkably low lung cancer incidence among South Asians.

Stomach cancer rates were high among Koreans, Chinese, Japanese, and Vietnamese. Koreans had the highest rates, nearly five times higher than non-Hispanic whites. The high risk for Koreans compared to other countries in Asia is confirmed by global incidence rates provided by GLOBOCAN[29]. The primary identified cause of non-cardia stomach cancer is infection with *Helicobacter pylori*. Interestingly, stomach cancer rates in South Asian and

Filipino subpopulations were similar to non-Hispanic whites despite a high prevalence of adult *H. pylori* infection in their countries of origin[30,31]. The extremely high vulnerability observed in Korean and other Asian subgroups could be related to a high dietary salt intake, which may enhance *H. pylori* colonization, alter gastric mucus viscosity, or damage gastric epithelium, all of which facilitate the development of stomach cancer[32,33].

Liver cancer rates were higher than those of non-Hispanic whites in all Asian subgroups except South Asian men. The highest rates, almost five times higher, were observed in the Vietnamese subpopulation. Infection with hepatitis B virus (HBV) is the major cause of liver cancer in Asia and developing countries, while in the US, hepatitis C virus (HCV) is the more common viral cause. Nonetheless, the Vietnamese American population has a high prevalence, 14%, of chronic HBV infection[34], which may partially be attributed to the absence of newborn hepatitis B vaccination in Vietnam until 2012[35]. Moreover, the 6% prevalence of HCV infection in Vietnam is high compared to the average prevalence of 2% for most other Asian countries[34]. These trends may account for the observed high rates among Vietnamese in our study. In general, populations in Asia have a higher risk of liver cancer because they tend to acquire HBV and HCV infection at a young age[34]. South Asians in our study have relatively low liver cancer incidence, which may be attributed to a lower prevalence of both HBV (3%) and HCV (1%-1.5%) infections in South Asia compared to other countries in East and Southeast Asia[36,37]. Notably, the predominant mode of transmission of HBV and HCV in India is blood transfusion and the use of unsafe therapeutic injection rather than the usual vertical transmission at the time of birth, most common in Asia[38,39]. There are several other risk factors associated with liver cancer, such as alcohol use, smoking, and obesity. However, given the lower prevalence of binge drinking, smoking, and obesity among Asian Americans[21], viral infection is the most likely cause for the heavy burden of liver cancer in specific Asian subgroups. Since liver cancer has a poor prognosis, more action to screen for and prevent the progression of hepatitis B and C among certain Asian subgroups, especially the Vietnamese, is warranted.

Nasopharyngeal cancer rates were strikingly high among Chinese, Vietnamese, and Filipino subgroups. The highest rates, observed in Chinese, were more than 13 times higher than those of non-Hispanic whites. Infection with *Epstein-Barr* virus (EBV) is associated with undifferentiated nasopharyngeal carcinoma[40]. Previous research indicates that the unusual high risk for nasopharyngeal cancer in certain Asian subgroups may be attributed to genetic predisposition and environmental factors that alter the oncogenic properties of EBV as well as increase susceptibility to environmental carcinogens[41,42]. When adjusted to the World Standard, the rates in our study for the Chinese subgroup (6.8/100,000 in men and 2.2/100,000 in women) were actually higher than those reported by GLOBOCAN for China (2.7/100,000 in men and 1.1/100,000 in women)[29]. The first generation of Chinese Americans came mainly from China's Guangdong Province where nasopharyngeal carcinoma rates are much higher than in other provinces[43]. Moreover, nasopharyngeal cancer is known to occur with obvious familial aggregation[43]. These patterns may contribute to our observed elevated rates. In any case, further studies on nasopharyngeal carcinoma in Asian subgroups should be conducted to clarify this increased risk.

Cervical cancer rates were high in the Vietnamese subgroup only. This finding is baffling given prior studies showing Vietnamese women with the highest cervical screening test (Pap) usage (76% in 2007) among all Asian subgroups[21]. Low English proficiency, low educational attachment, and high poverty rates among Vietnamese women may adversely impact their receipt of assistance with cervical cancer control[21,44]. We could not find any literature on the prevalence of HPV infection and its oncotypes among the Vietnamese subgroup.

Thyroid cancer rates were relatively high among Filipinos compared to other Asian subgroups and non-Hispanic whites, although the reasons are unclear. Risk factors include a history of goiter or thyroid nodules and lower soy isoflavone consumption[45]. Due to early clinical detection and diagnosis, multiple countries including the US have experienced a substantial increase in thyroid cancer incidence without a concomitant increase in mortality[46,47]. While Filipinos have a higher healthcare access rate and lower poverty rate than other Asian subgroups[21], it is unlikely that increased detection alone would explain this higher risk for thyroid cancer.

The role of acculturation in explaining some of the variability in our observed results cannot be directly measured. However, it is worth noting that the Japanese, who have the longest history in the US, seem to have intermediate rates between those of other Asian subgroups and non-Hispanic whites for prostate, breast, and uterine cancer. Their colorectal cancer rates actually surpass those of non-Hispanic whites in our study. These cancers are often associated with a Western lifestyle. Yet the rates for liver and stomach cancer for the Japanese subgroup remain higher than those of non-Hispanic whites. This suggests that the process of cancer risk conversion from culture of origin to the dominant culture is complex and spans more than one generation. To a lesser extent, the Filipino subgroup also shows a pattern consistent conversion in cancer risk due to acculturation. South Asians seem to be the most distinct of all subgroups and show overall the lowest risk for cancer among men, with remarkably low rates of lung and colorectal cancers. Aside from a low smoking rate and dominant vegetarian diet[21,48], the causes of this apparent lack of vulnerability, especially for colorectal cancer, are worth further study.

Overall, these results complement previously published research[7-9]. In the most recent publication on this subject, Gomez et al. reported incidence rates by Asian subgroup for five of the most common cancer sites for the period 2004-2008[7]. Our rates for 2009-2011 are not dissimilar after taking into account the decreasing trends for cancer incidence in Asian men and the stable trends in Asian women reported in the most recent Annual Report on Cancer[49].

A significant strength of this study is that it provides rates for the largest coverage to date of Asian Americans, more than two thirds of the overall total national Asian population, by using cancer registry data from both SEER and NPCR. Out of the total US Asian population of 14.7 million, 73% of Chinese, 79% of Filipino, 78% of Japanese, 65% of Korean, 63% of South Asian, and 65% of Vietnamese American populations were covered. The inclusion of the NPCR data in our study increased the coverage of all Asian subgroups, especially South Asians, whose coverage was doubled. An additional strength is our application of an

equitable and unbiased method to impute Asian NOS cases, which accounted for 15% of Asian cancer cases. We address the specificities of NAACCR data collection on Asians with new methodology building on previous work by Pinheiro et al.[18]. By accounting for NOS cases, the overall rates are approximately 5%-6% higher than those based on the current race descriptors and algorithm. However, the increment varies considerably by cancer site, and is as high as 9% for cancers with better prognosis, such as thyroid, breast, and prostate cancers. In summary, this study is the first to provide incidence rates that are directly comparable among specific Asian subgroups as well as between them and other US reference populations.

NAACCR designed the NAACCR Asian/Pacific Islander Identification Algorithm (NAPIIA) to reduce Asian NOS cases[17]. NAPIIA uses name and birthplace to enhance the race identification among Asian NOS cases indirectly. However, its use in this study would have introduced bias in the allocation of Asian NOS cases because the coverage of the name and surname portion of the algorithm is not uniform across major specified Asian subgroups and is absent among OSA subgroups. In practice, its use in this study would have substantially overestimated Chinese cancer rates and underestimated South Asian rates (data not shown).

Several limitations may have affected our results. The estimates assume that NOS cases occur randomly across all Asian subgroups who share the same sex, cancer site, age group, and geographic region. While this is the most logical assumption, it is possible that the reality may be somewhat different. The precision of our confidence intervals may be overestimated because our imputation model does not account for the uncertainty of the observed NOS counts. Another possible limitation is that race/ethnicity data from cancer registries are derived from medical records and administrative information while data from the Census are based on self-identifications alone. The two may not be totally comparable. Also, birthplace was used to improve identification of specified Asians and estimate OSAs, but the availability of birthplace data may not be uniform across Asian subgroups. Finally, due to limited access to Race 2 data, estimates in Florida were strictly based on Race 1. However, given the comparatively low number of Asian cases in Florida, it is unlikely that this affected our results.

This study portrays unique cancer incidence patterns among specific Asian subgroups and provides a reliable baseline for future cancer surveillance research and health policy. Complex phenomena like acculturation and cancer risk conversion may help explain why rates for certain cancers remain higher than average among Asian Americans while cancer risk for the leading four cancers appears to be converging with US averages[15,50]. Nonetheless, these analyses on the heterogeneity of cancer profiles among Asian subgroups can provide unique opportunities to better understand the epidemiology of these cancers as well as facilitate future research hypotheses. The variations observed require future research to explore cancer susceptibility among Asian American subgroups. In addition, this study highlights the critical importance of public health efforts that target cancer disparities among Asian subgroups through improved surveillance and prevention efforts, including screening and community-based education.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Abbreviations used

US	United States
SEER	Surveillance, Epidemiology, and End Results Program
NPCR	National Program of Cancer Registries
NOS	not-otherwise-specified
NAACCR	North American Association of Central Cancer Registries
OSA	other specified Asian
CI	confidence interval
IRB	Institutional Review Board
PSA	prostate-specific antigen
HBV	hepatitis B virus
HCV	hepatitis C virus
EBV	*Epstein-Barr* virus

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Novelty and Impact

This is the most comprehensive study to date on cancer incidence among Asian American subgroups in the US, with the novelty of using both SEER and NPCR data, ensuring a broader representation of US Asian Americans. It also is the first study to estimate balanced incidence rates by accounting for Asian cancer cases with unknown subgroup using an imputation model, providing unbiased comparisons across different Asian subgroups and between these Asian subgroups and non-Hispanic whites.

Table 1

Selected states and respective cancer registries and geographic regions

State	SEER registry	NPCR registry	Geographic region
California	Los Angeles Registry		Los Angeles County
	San Francisco-Oakland Registry		Bay Area Region[†]
	San Jose-Monterey Registry		Santa Clara Region[‡]
	Greater California Registry[*]	Greater California Registry[*]	Greater California[§]
Florida		Florida Cancer Data System	Florida
Hawaii	Hawaii Registry		Hawaii
Illinois		Illinois State Cancer Registry	Illinois
New Jersey	New Jersey Registry[*]	New Jersey Registry[*]	New Jersey
New York		New York Cancer Registry	New York
Texas		Texas Cancer Registry	Texas
Washington	Seattle-Puget Sound Registry	Washington State Cancer Registry[‖]	Washington

[*] Funded by both SEER and NPCR

[†] Bay Area Region includes Alameda, Contra Costa, Marin, San Francisco, and San Mateo Counties

[‡] Santa Clara Region includes Monterey, San Benito, Santa Clara, and Santa Cruz Counties

[§] Greater California includes Central California, Sacramento, Tri-County, Desert Sierra, Northern California, and San Diego/Imperial

[‖] Only non-SEER area data were obtained

Table 2

Distribution of Asian and non-Hispanic white cancer cases before and after stratified imputation, 8 states, 2009-2011

	Chinese	Filipino	Japanese	Korean	South Asian	Vietnamese	Other Asian*	Asian NOS	Asian Total	NH White
California	11,703	12,092	4,133	3,610	3,067	4,749	1,440	5,922	46,716	297,448
	13,132	13,699	4,604	4,018	3,593	5,393	2,277	0		
Florida	247	417	113	116	641	321	67	970	2,892	244,747
	373	640	163	179	902	469	166	0		
Hawaii	1,130	2,826	4,755	423	19	73	46	92	9,364	5,910
	1,140	2,858	4,799	427	19	74	47	0		
Illinois	457	766	129	402	1,246	142	82	986	4,210	150,289
	594	995	165	518	1,598	177	163	0		
New Jersey	856	1,029	123	701	1,651	155	28	556	5,099	110,185
	964	1,143	134	774	1,831	172	81	0		
New York	5,290	1,119	272	954	2,865	284	200	1828	12,812	233,818
	5,974	1,277	312	1,083	3,362	328	476	0		
Texas	485	402	157	282	1,077	872	95	2029	5,399	197,509
	828	630	227	431	1,710	1,333	240	0		
Washington	549	705	484	528	237	430	228	1056	4,217	87,821
	727	945	614	678	333	549	371	0		
Total	20,717	19,356	10,166	7,016	10,803	7,026	2,186	13,439	90,709	1,327,727
	23,732	22,187	11,018	8,108	13,348	8,495	3,821	0		

*Other Asian before stratified imputation includes Hmong, Kampuchean, Laotian, and Thai; Other Asian after stratified imputation includes Hmong, Kampuchean, Laotian, Thai, and Other Specified Asian

Table 3

Age adjusted cancer incidence rates and 95% confidence intervals (CIs) by Asian subgroup and non-Hispanic whites, 2009-2011, men*

	Chinese		Filipino		Japanese		Korean		South Asian		Vietnamese		Asian Total		NH White	
	N	Rate (95% CI)	N	Rate (95% CI)	N	Rate (95% CI)	N	Rate (95% CI)	N	Rate (95% CI)	N	Rate (95% CI)	N	Rate (95% CI)	N	Rate (95% CI)
Oral	513	13.5 (12.4-14.8)	254	9.1 (8.0-10.4)	144	11.6 (9.7-13.8)	72	6.5 (5.0-8.2)	363	15.3 (13.4-17.3)	168	12.0 (10.2-14.1)	1,596	11.7 (11.1-12.3)	24,690	19.0 (18.7-19.2)
Nasopharynx	299	8.0 (7.1-9.0)	98	3.5 (2.8-4.3)	8	0.8 (0.3-1.8)	11	0.9 (0.4-1.7)	27	1.1 (0.7-1.6)	85	5.9 (4.7-7.4)	567	4.1 (3.8-4.5)	685	0.6 (0.6-0.7)
Stomach	612	17.1 (15.7-18.5)	183	8.0 (6.8-9.3)	255	18.0 (15.8-20.5)	411	37.8 (34.1-41.9)	180	8.0 (6.7-9.5)	168	15.8 (13.3-18.7)	1,894	15.9 (15.2-16.7)	10,280	8.2 (8.0-8.3)
Colorectal	1,509	41.7 (39.6-43.9)	1,175	46.6 (43.8-49.5)	768	59.5 (55.2-64.0)	555	49.5 (45.2-54.0)	593	28.1 (25.5-31.0)	560	46.2 (42.0-50.5)	5,415	43.1 (41.9-44.3)	59,446	47.5 (47.1-47.8)
Liver	869	22.9 (21.4-24.5)	433	17.5 (15.8-19.3)	188	13.8 (11.9-16.1)	304	26.3 (23.3-29.6)	235	10.3 (8.8-11.9)	681	52.8 (48.7-57.3)	2,947	22.4 (21.6-23.2)	13,486	10.1 (9.9-10.3)
Pancreas	361	10.4 (9.3-11.5)	261	10.9 (9.5-12.3)	199	14.8 (12.7-17.1)	131	12.6 (10.4-15.1)	149	8.0 (6.5-9.6)	119	10.4 (8.5-12.6)	1,272	10.8 (10.2-11.5)	18,554	14.6 (14.3-14.8)
Lung	1,783	51.2 (48.8-53.6)	1,458	62.9 (59.5-66.4)	598	44.1 (40.5-48.0)	437	43.7 (39.4-48.2)	510	27.1 (24.4-30.0)	751	67.0 (61.9-72.4)	5,751	49.6 (48.3-51.0)	95,679	75.3 (74.8-75.8)
Prostate	2,280	63.0 (60.4-65.7)	2,693	105.2 (101.0-109.4)	1,174	90.1 (84.9-95.6)	551	49.3 (45.0-53.8)	1,714	80.6 (76.3-85.1)	615	53.3 (48.9-58.0)	9,311	74.5 (72.9-76.1)	174,028	130.2 (129.6-130.8)
Bladder	520	15.2 (13.9-16.6)	280	12.3 (10.9-13.9)	289	21.0 (18.6-23.7)	217	21.7 (18.7-25.0)	308	16.8 (14.6-19.1)	110	9.9 (8.0-12.1)	1,780	15.8 (15.1-16.6)	51,709	41.4 (41.0-41.7)
Kidney	363	9.9 (8.9-11.0)	421	15.7 (14.1-17.3)	192	15.5 (13.3-18.0)	135	12.3 (10.2-14.7)	280	11.6 (10.0-13.2)	115	8.7 (7.1-10.6)	1,562	12.0 (11.4-12.6)	28,013	22.2 (21.9-22.4)
Thyroid	263	6.9 (6.1-7.8)	271	9.7 (8.5-11.0)	41	3.7 (2.6-5.2)	108	8.3 (6.8-10.1)	186	5.8 (4.9-6.8)	75	5.3 (4.1-6.7)	974	6.8 (6.4-7.3)	9,425	8.1 (7.9-8.3)
NHL	557	15.6 (14.3-16.9)	498	20.4 (18.5-22.3)	215	16.9 (14.6-19.5)	131	11.8 (9.7-14.1)	381	18.0 (15.8-20.3)	204	17.1 (14.7-19.9)	2,070	16.7 (16.0-17.5)	30,855	25.2 (25.0-25.5)
Leukemia	279	8.0 (7.1-9.0)	285	12.2 (10.7-13.8)	125	10.5 (8.6-12.8)	93	8.3 (6.6-10.2)	295	13.4 (11.6-15.4)	175	14.9 (12.6-17.5)	1,298	10.5 (9.9-11.1)	22,178	18.6 (18.4-18.9)
Other-sites combined	1,409	39.9 (37.8-42.1)	1,165	47.0 (44.2-49.9)	609	49.7 (45.5-54.2)	500	46.2 (42.0-50.7)	1,256	54.8 (51.1-58.6)	565	48.4 (44.1-53.0)	5,825	46.6 (45.4-47.9)	146,674	121.7 (121.1-122.3)
All-sites combined	11,318	315.3 (309.5-321.3)	9,377	377.4 (369.4-385.5)	4,798	369.1 (358.3-380.2)	3,644	334.1 (322.7-345.8)	6,450	297.7 (289.1-306.4)	4,306	361.9 (350.2-373.8)	41,695	336.5 (333.1-339.8)	685,017	541.9 (540.6-543.3)

*Rates are average annual per 100,000 age standardized to the 2000 US population. Oral= oral cavity and pharynx; Liver= liver and intrahepatic bile duct; Lung=lung and bronchus; Bladder=urinary bladder; Kidney= kidney and renal pelvis; NHL=non-Hodgkin lymphoma; Numbers of cases may not add up to total due to rounding

Table 4

Age adjusted cancer incidence rates and 95% confidence intervals (CIs) by Asian subgroup and non-Hispanic whites, 2009-2011, women*

	Chinese		Filipino		Japanese		Korean		South Asian		Vietnamese		Asian Total		NH White	
	N	Rate (95% CI)	N	Rate (95% CI)	N	Rate (95% CI)	N	Rate (95% CI)	N	Rate (95% CI)	N	Rate (95% CI)	N	Rate (95% CI)	N	Rate (95% CI)
Oral	268	6.0 (5.3-6.8)	145	3.8 (3.2-4.5)	80	4.1 (3.2-5.3)	34	2.1 (1.4-3.0)	140	6.5 (5.4-7.8)	81	5.6 (4.4-7.0)	801	4.9 (4.6-5.3)	10,145	7.0 (6.9-7.2)
Nasopharynx	108	2.5 (2.0-3.0)	41	1.1 (0.8-1.5)	6	0.4 (0.1-0.9)	5	0.3 (0.1-0.8)	8	0.4 (0.1-0.8)	27	1.9 (1.2-2.8)	211	1.3 (1.1-1.5)	300	0.2 (0.2-0.3)
Stomach	399	9.2 (8.3-10.2)	166	4.5 (3.8-5.2)	242	10.7 (9.3-12.4)	288	18.8 (16.7-21.2)	106	5.3 (4.2-6.6)	138	11.2 (9.3-13.4)	1,384	8.9 (8.4-9.4)	5,779	3.7 (3.6-3.8)
Colorectal	1,372	31.3 (29.7-33.0)	1,201	31.6 (29.8-33.5)	819	40.5 (37.5-43.6)	545	34.4 (31.5-37.5)	444	22.3 (20.0-24.7)	466	34.2 (31.0-37.7)	5,037	31.6 (30.7-32.5)	56,042	36.5 (36.2-36.8)
Liver	351	8.3 (7.4-9.2)	209	5.8 (5.0-6.7)	161	7.0 (5.9-8.3)	144	9.7 (8.1-11.5)	96	4.7 (3.7-5.8)	188	15.5 (13.3-18.0)	1,244	8.1 (7.6-8.6)	5,125	3.4 (3.3-3.5)
Pancreas	338	8.0 (7.2-8.9)	337	9.4 (8.4-10.5)	281	12.4 (10.9-14.2)	150	10.0 (8.4-11.8)	119	6.4 (5.2-7.7)	97	8.4 (6.7-10.3)	1,370	9.0 (8.6-9.5)	17,407	10.9 (10.8-11.1)
Lung	1,370	31.7 (30.0-33.4)	1,100	29.4 (27.7-31.3)	669	30.5 (28.1-33.1)	426	27.9 (25.3-30.8)	279	14.9 (13.0-17.0)	409	31.7 (28.6-35.1)	4,439	28.6 (27.8-29.5)	91,035	59.4 (59.0-59.8)
Breast	3,773	82.8 (80.1-85.5)	4,562	111.3 (108.0-114.7)	2,065	127.8 (122.0-133.8)	1,307	75.6 (71.4-79.8)	2,566	106.3 (101.9-110.9)	1,147	72.2 (67.9-76.6)	16,022	94.5 (93.0-96.0)	188,181	134.4 (133.8-135.1)
Premenopausal	1,251	28.8 (27.2-30.5)	1,179	33.2 (31.3-35.1)	462	42.7 (38.9-46.8)	468	27.9 (25.4-30.6)	931	31.0 (29.0-33.1)	439	26.4 (24.0-29.1)	4,949	30.1 (29.3-31.0))	31,961	34.3 (33.9-34.6)
Postmenopausal	2,522	53.9 (51.8-56.1)	3,383	78.1 (75.4-80.9)	1,603	85.1 (80.8-89.6)	839	47.7 (44.4-51.1)	1,635	75.4 (71.4-79.4)	708	45.7 (42.2-49.4)	11,073	64.4 (63.2-65.6)	156,220	100.2 (99.7-100.7)
Cervix Uteri	249	5.6 (4.9-6.4)	280	7.2 (6.4-8.1)	85	6.6 (5.2-8.3)	119	7.2 (5.9-8.6)	135	5.5 (4.5-6.6)	132	9.0 (7.5-10.8)	1,094	6.5 (6.1-6.9)	8,436	7.5 (7.3-7.6)
Corpus and uterus	730	15.3 (14.2-16.5)	1,109	26.5 (24.9-28.1)	379	22.8 (20.5-25.4)	171	9.6 (8.2-11.2)	519	22.0 (20.0-24.2)	230	14.3 (12.4-16.3)	3,250	18.7 (18.0-19.3)	38,969	26.6 (26.3-26.9)
Ovary	414	9.0 (8.1-9.9)	395	10.1 (9.1-11.1)	138	8.3 (6.9-10.1)	147	8.8 (7.4-10.4)	319	13.5 (11.9-15.2)	147	10.3 (8.6-12.2)	1,627	9.7 (9.3-10.2)	18,634	13.1 (12.9-13.3)
Bladder	190	4.5 (3.8-5.2)	101	2.8 (2.3-3.5)	118	5.0 (4.1-6.1)	46	3.3 (2.4-4.5)	92	5.3 (4.2-6.6)	33	2.8 (1.9-4.0)	593	3.9 (3.6-4.2)	16,175	10.3 (10.1-10.4)
Kidney	211	4.9 (4.3-5.6)	232	6.0 (5.3-6.9)	113	6.0 (4.8-7.4)	65	4.2 (3.2-5.4)	130	5.8 (4.8-7.0)	66	4.6 (3.5-5.9)	843	5.3 (4.9-5.6)	15,937	11.1 (11.0-11.3)
Thyroid	920	20.8 (19.4-22.2)	1,108	28.5 (26.8-30.3)	153	11.6 (9.7-13.9)	408	23.2 (21.0-25.6)	624	19.9 (18.3-21.7)	318	19.3 (17.2-21.7)	3,670	21.5 (20.8-22.2)	25,325	22.4 (22.1-22.7)
NHL	463	10.5 (9.5-11.5)	528	14.1 (12.9-15.4)	249	11.8 (10.2-13.6)	129	8.2 (6.8-9.7)	274	12.4 (10.8-14.2)	167	12.1 (10.3-14.2)	1,884	11.7 (11.2-12.3)	25,493	17.3 (17.0-17.5)
Leukemia	228	5.6 (4.8-6.4)	269	7.8 (6.9-8.8)	94	6.4 (4.8-8.2)	60	4.0 (3.0-5.2)	195	8.7 (7.3-10.1)	111	7.9 (6.4-9.5)	998	6.5 (6.1-6.9)	16,132	11.4 (11.2-11.5)
Other-sites combined	1,138	26.7 (25.2-28.3)	1,068	29.6 (27.8-31.5)	574	31.1 (28.1-34.3)	425	29.0 (26.2-32.0)	862	40.1 (37.1-43.3)	462	34.1 (30.9-37.5)	4,758	30.3 (29.4-31.2)	103,894	74.2 (73.8-74.7)
All-sites combined	12,414	280.1 (275.2-285.2)	12,810	328.6 (322.8-334.4)	6,218	342.7 (333.5-352.3)	4,464	275.9 (267.7-284.4)	6,898	299.6 (291.8-307.6)	4,189	293.2 (283.9-302.7)	49,014	299.6 (296.9-302.3)	642,710	449.3 (448.2-450.4)

*Rates are average annual per 100,000 age standardized to the 2000 US population. Oral= oral cavity and pharynx; Liver= liver and intrahepatic bile duct; Lung=lung and bronchus; Bladder=urinary bladder; Kidney= kidney and renal pelvis; NHL=non-Hodgkin lymphoma; Numbers of cases may not add up to total due to rounding