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Cancer among Asian American Population in the United States: Incidence and Survival Disparities

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CANCER AMONG ASIAN AMERICAN POPULATION IN THE UNITED STATES: INCIDENCE AND SURVIVAL DISPARITIES

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Abstract

Cancer among Asian American Population in the United States:

Incidence and Survival Disparities

by

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Part I

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.

Part II

Globally, Asian countries bear a disproportionate gastric cancer burden. Asian Americans, the fastest growing minority population in the US, show not only higher incidence of gastric cancer compared to non-Hispanic whites (NHWs), but also significantly higher survival. Benefiting from more uniform staging and treatment practices within the US, we examine for the first time the heterogeneity in the Asian American population, which may elucidate the causes of these disparities. SEER data from 2000 to 2012 were used to calculate 5-year survival estimates for NHWs and the six largest Asian ethnicities. Multivariate analyses were performed to identify critical prognostic factors and survival disparities between Asian groups and NHWs. We analyzed 33,313 NHW and 8,473 Asian gastric cancer cases. All Asian groups had significantly higher 5-year survival than NHWs, at 29.8%. Among Asians, Koreans and Vietnamese had the highest and lowest survival, 45.4% and 35.7%, respectively. The Korean survival advantage was largely attributable to relatively high proportions of localized stage and low proportions of cardia tumors. After adjusting for major prognostic factors, the survival disadvantage of NHWs, while attenuated, remained significant in comparison to all Asian groups (HR: 1.33; 95% CI: 1.24-1.43; reference:

Korean). The survival disparities within the Asian groups vanished with adjustment. This study characterizes distinctive gastric cancer survival patterns among the six major Asian groups and NHWs in the US. The causes of the survival disadvantage for NHWs remain elusive. The observed survival disparity affecting NHW in relation to Asians points to the need for increased awareness of gastric cancer screening and treatment options of NHWs, who account for the majority of cases.

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Chapter 1

Introduction

Cancer is the second leading cause of death in the United States (US), accounting for approximately 23% of deaths in 2011 (CDC, 2012a). Although the death rate for cancer in the US has been exhibiting a gradual but consistent descending trend since 1993 (CDC, 2010), many population groups across the US suffer disproportionately from cancer and benefit less from cancer control and prevention. In 2000, the Minority Health and Health Disparities Research and Education Act defined health disparities as

> *"A population is a health disparity population if there is a significant disparity in the overall rate of disease incidence, prevalence, morbidity, mortality or survival rates in the population as compared to the health status of the general population." (United States Public Law 106-525, p. 2498)*

With the promulgation of US Public Law 106-525, the National Cancer Institute (NCI) defines cancer health disparities as "adverse differences in cancer incidence, cancer prevalence, cancer death, cancer survivorship, and burden of cancer or related health conditions that exist among specific population groups in the US" (NCI, 2008). A variety of factors have been researched to characterize these underserved population groups. Among them, race/ethnicity is one of the most widely accepted factors to understand cancer health disparities and becomes one of the criteria to fund and shape public health intervention programs against cancer (National Academies of Sciences, Engineering, and Medicine, 2002).

The Asian American population grew faster than any other racial/ethnic group in the US over the last decade, representing 5.6% of the US population (US Census, 2012a). Oftentimes, they are

considered a model minority because of their remarkable economic and educational success as well as social assimilation (Gomez et al., 2013). According to the 1999-2010 Cancer Report from US Cancer Statistics (USCS, 2015), Asian and Pacific Islanders (APIs) have significantly lower overall incidence and mortality than non-Hispanic whites, non-Hispanic blacks, and Hispanics. Given the impression of model minority and superior overall cancer statistics, Asian Americans are routinely considered to bear less burden of cancer than the general population. However, these misleading stereotypes might obscure health disparities among Asian Americans and mask many unmet public health needs including hampering battles against cancer.

The US Asian American population is comprised of numerous subgroups with different geographic origins. The majority of Asian Americans in the US came from over 50 different countries and speak over 100 different languages, of which 36.2% arrived in the US in 2000 or later (US Census, 2012a). This immigrant-dominant population carries distinctive cancer profile prevalent in Eastern countries, characterized by high prevalence in cancers of infectious origin, such as stomach cancer, liver cancer, and cervical cancer (Miller, Chu, Hankey, & Ries, 2008; Gomez et al., 2013). Also, with the assimilation into the US mainstream culture, their original lifestyles are challenged by their western counterparts, resulting in increased risk of diseases of civilization, such as breast cancer (Chia et al., 2005; Gomez et al., 2010).

By virtue of different cultural backgrounds, lifestyles, and immigration histories, cancer incidence and survival among US Asian American population are dramatically heterogeneous (Pineda, White, Kristal, & Taylor, 2001; Lin et al., 2002; Kwong, Chen, Snipes, Bal, & Wright, 2005; Chang et al., 2007; McCracken et al., 2007; Miller et al., 2008; Ou, Ziogas, & Zell, 2009; Le, Ziogas, Taylor, Lipkin, & Zell, 2009; Goggins & Wong, 2009; Gomez, et al., 2010; Gomez et al., 2013). However, cancer health disparities among specific Asian subgroups have been

infrequently studied mostly due to the complexity and difficulty in collecting data on race/ethnicity by cancer registries (Nguyen, Chawla, Noone, & Srinivasan, 2014; Gomez et al., 2014) and lack of comparably-detailed population estimates (McCracken et al., 2007; Miller et al., 2007). The North American Association of Central Cancer Registries (NAACCR) has published guidelines for collecting and coding race/ethnicity data, which allow recording detailed Asian subgroups. In addition, new procedures, such as the NAACCR Asian and Pacific Islander Identification Algorithm (NAPIIA), have been suggested to enhance the identification of detailed subgroups in Asian Americans. However, a noteworthy fraction of cancer cases among US Asian Americans have unknown detailed subgroup, with proportions that have been steadily rising over the last decades. On the other hand, detailed and accurate population estimates for detailed Asian subgroups are accessible only from the decennial US Census. As a result, national statistics on cancer for specific Asian subgroups are not routinely available (McCracken et al., 2007).

Revealing cancer health disparities among Asian Americans requires accurate incidence and survival estimates for each specific Asian subgroup. However, dominant cancer research literature tends to aggregate Asian subgroups into one large group, which obscures the diversity and complexity of Asian Americans. Of those examined descriptive epidemiology of cancer by specific Asian subgroup (Deapen , Liu, Perkins, Bernstein, & Ross, 2002; Chang et al., 2007; McCracken et al., 2007; Miller et al., 2008; Raz et al., 2008; Chang et al., 2009; Ou et al., 2009; Keegan et al., 2010; Wang, Carreon, Gomez, & Devesa, 2010; Gomez et al., 2010; Horn-Ross et al., 2011; Clarke et al., 2011; Liu, Zhang, Wu, Pike, & Deapen, 2012; Gomez et al., 2013), cancer data from the Surveillance, Epidemiology, and End Results (SEER) Program were favored due to its reputation for validity and convenience. However, SEER only covers up to approximately 50% of US Asian American and 65.8% of them reside in California (US Census, 2012a). Therefore, using SEER's

population bases solely may not be able to provide a robust assessment on cancer health disparities in Asian Americans. Besides, to the author's knowledge, no previous research study has taken Asian Americans with unknown detailed group into account. Statistical exclusion is the most common technique to treat such group due to lack of methods to effectively utilize categorical data with missing values. Yet, with the rapidly rising proportion of this group in cancer registry data, incidence rates for each detailed Asian subgroup are underestimated with varying magnitude. Moreover, US Census allows respondents to report more than one race since 2000, resulting in 4 different population estimates for each Asian subgroup (US Census, 2012a). This new feature facilitates research on multiracial populations while complicates computation of population denominators. Averaging groups with one race and multiple races will result in inflated population estimates and underestimated incidence rates.

Numerous studies have showed racial differences in deaths from cancer among non-Hispanic whites and Asian Americans (Wong et al., 1999; Pineda et al., 2001; Trinh et al., 2015). Racial disparities in cancer survival outcomes have been primarily attributed to underlying biologic mechanisms and the quality of cancer care received (Trinh et al., 2015). Among Asian subgroups, the uneven distribution of socioeconomic status (SES) and inequalities of care may also cause cancer survival disparities among specific Asian subgroups. Stomach cancer is the fifth most common cancer and the third leading cause of cancer death worldwide (International Agency for Research on Cancer, 2016). In the US, stomach cancer disproportionately affects Asian Americans (Gomez et al., 2013). However, very few literature has investigated the stomach survival difference among Asian subgroups in the US.

Overcoming cancer health disparities is one of the keystones to unload the burden of cancer in the US Investigation of cancer health disparities among detailed Asian subgroups is critical to

identify underserved populations and translate epidemiological knowledge into effective targeted cancer control programs. The goal of the present study is to investigate cancer incidence and stomach cancer survival disparities among major Asian subgroups (Chinese, Filipino, Japanese, Korean, South Asian, and Vietnamese) in the US.

Chapter 2

Background

Cancer

Cancer is one of the leading causes of death globally (World Health Organization, 2015). In 2012, there were 14.1 million new cancer cases, 8.2 million cancer deaths, and 32.6 million people living with cancer (diagnosed within 5 years) worldwide. The World Health Organization (WHO) estimated that the annual incident cases will rise to 22 million within the next two decades if action is not taken (IARC, 2012). Similar to other developed countries, the United States (US) has higher cancer incidence but lower death rate compared to global average (WHO, 2015). Despite relatively sufficient resources for cancer prevention, diagnosis and treatment, cancer remains the second leading cause of death in the US (CDC, 2013) and is expected to cause approximately 1.7 million incident cases and 0.6 million deaths in 2016 (American Cancer Society, 2016).

Although the causes of cancer are still unclear, but cancer research has indicated that they are a combination of genetic factors, lifestyle factors, certain types of infections, and environmental exposures (American Cancer Society, 2016). Previous research studies have shown that only 5-10% of all cancer cases are attributable to genetic defects, whereas the remaining 90-95% are caused by interaction with environment (Figure 1) (Mucci, Wedren, Tamimi, Trichopoulos, & Adami, 2001; Czene & Hemminki, 2002; Anand et al., 2008). The major known environmental factors include tobacco use, diet, infection, obesity or physical inactivity, alcohol use, certain chemicals, and radiation. These findings form the basis of contemporary cancer prevention and control and ascertain that cancer is largely preventable (Anand et al., 2008).

Tobacco

Smoking, as well as secondhand smoke, has been linked to increased risk for many kinds of cancer, such as lung cancer, head and neck cancer, bladder cancer, kidney cancer, leukemia, and breast cancer (WHO, 2004a). Lung cancer is the leading cause of cancer death and the second most common cancer in the US for both men and women (American Cancer Society, 2016). Not smoking or quitting smoking lowers the risk of getting cancer and dying from cancer. Smoking rates differ significantly by race in the US (CDC, 2014a). According to the US National Health Interview Survey 2005-2014, Asian adults had the lowest prevalence of current cigarette smokers (9.5%) compared with the national average (16.8%) in 2014. The smoking rates among detailed Asian subgroups have not been updated lately, but findings from the National Survey on Drug Use and Health, 2002-2005 showed that tobacco product use varied significantly among detailed Asian subgroups (Table 1). Vietnamese and Koreans had higher frequency of using tobacco products than other Asian subgroups (Caraballo, Yee, Gfroerer, & Mirza, 2008).

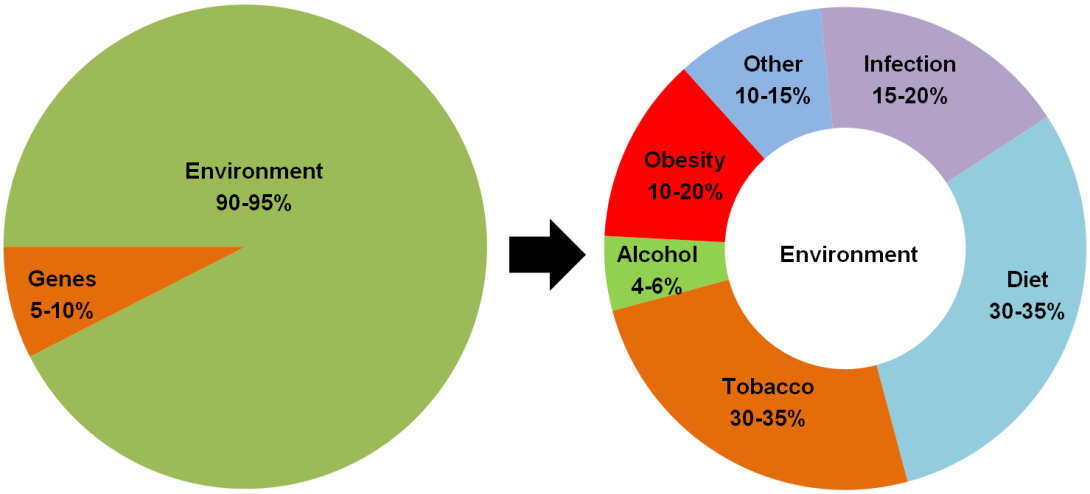


Figure 1. The role of genes and environment in the development of cancer

Source: Cancer is a preventable disease that requires major lifestyle changes, Anand et al., 2008)

Table 1. Percent of respondents aged 18 or older who used tobacco products during the past 30 days, 2002–2005

Population	Tobacco Use Rate (%)	95% CI
Non-Hispanic white	33.0	32.6-33.5
Total Asian	15.8	14.3-17.3
Chinese	10.0	7.8-12.8
Filipino	17.0	13.9-20.5
Asian Indian	12.8	10.0-16.4
Vietnamese	22.5	17.3-28.7
Korean	28.4	22.9-34.6
Japanese	15.2	11.5-19.9

Source: Adult tobacco use among racial and ethnic groups living in the United States, 2002-2005, Caraballo et al., 2008

Diet

The effects of diet on cancer risk vary drastically by cancer site (Willett, 2000). For example, up to 70% of colorectal cancer, the third most common cancer among men and women in the US, can be attributed to diet. Heavy consumption of fat, a characteristic of typical Western diet, has been linked to gastrointestinal cancer (Haggar & Boushey, 2009). Excessive fat benefits the growth of a bacterial flora capable of degrading bile salts into potentially carcinogenic N-nitroso compounds (NOCs). Endogenous NOC formation can be promoted by heme iron in red meat and inhibited by vitamin C in fruit and vegetables (Dubrow et al., 2010).

Traditional Asian diet, characterized by predominantly rice and whole grains, abundant fruits and vegetables, and moderate meat and fish consumption, is considered to be healthy and cancer-preventing. A variety of common ingredients in Asian cuisine, such as isoflavone in soybean, catechin in tea, and curcumin in curry, have demonstrated protective effects against cancer in many epidemiological studies (Yamamoto, Sobue, Kobayashi, Sasaki, & Tsugane, 2003; Basnet & Skalko-Basnet, 2011; Yuan, 2013). However, certain diet habits in Asians, such as favoring fermented foods high in salt and NOCs and raw seafood, may also increase the risk for

gastrointestinal cancer and cancers of infectious origin (Ananthakrishnan, Gogineni, & Saeian, 2006; Shin, Kim, & Park, 2011)

Infection

Certain viruses and bacteria can cause cancer directly or indirectly (NCI, 2015). For example, Human papillomavirus (HPV) is well known for causing cervical cancer, as well as cancers in penis, vagina, anus, and oropharynx (Lowy & Schiller, 2012). Hepatitis B (HBV) and hepatitis C viruses (HCV) can cause cirrhosis and increase the risk for liver cancer (Nguyen & Keeffe, 2003). Helicobacter pylori increases the risk for stomach cancer (World Gastroenterology Organization, 2010). Worldwide, nearly 17.8% of cancer is associated with infectious diseases (Anand et al., 2008). Despite the presence of effective vaccines (HBV and HPV), screening (mammogram, pap smear and gastroscopy) and diagnostic tools (urea breathe test for H. Pylori and DNA test for HPV), US Asian Americans are disproportionately affected by infection-related cancers, particularly cancers of the cervix, stomach, liver, and nasopharynx (McCracken et al., 2007), which is primarily ascribed to foreign-born Asians who acquired infections in their countries of origin.

Obesity

Obesity has been associated with higher risk of colorectal cancer, postmenopausal breast cancer, endometrial cancer, kidney cancer, esophageal cancer, and pancreatic cancer (NCI, 2015). A national perspective cohort study in the US demonstrated that 14% of all cancer deaths in men of 50 years of age or older and 20% in women of 50 years of age or older can be attributed to overweight or obesity (Calle, Rodriguez, Walker-Thurmond, & Thun, 2003). Generally, Asian Americans are considered carrying less burden of obesity due to their healthier lifestyles.

According to the Summary Health Statistics for US Adults, 2011 (CDC, 2012b), Asian Americans of 18 years of age and over were 12% and 65% less likely to be overweight and obese than non-Hispanic whites, respectively. However, rates of overweight and obesity vary greatly among detailed Asian subgroups (Table 2). Filipinos and Asian Indians had higher overweight rates than the other Asian subgroups, which were similar to non-Hispanic whites (CDC, 2008). Filipinos also had higher obesity rate than the other Asian subgroups.

Table 2. Age-adjusted percent distributions of overweight and obese for Asian American of 18 years of age and over, 2004–2006

Population	Overweight (%)	Obese (%)
Non-Hispanic white	34.6%	23.6%
Total Asian	27.5%	8.1%
Chinese	21.8%	4.2%
Filipino	33.0%	14.1%
Asian Indian	34.4%	6.0%
Vietnamese	19.1%	5.3%
Korean	27.3%	2.8%
Japanese	25.9%	8.7%

Source: Health Characteristics of the Asian Adult Population: United States, 2004-2006. CDC, 2008

Alcohol

Studies have revealed that chronic moderate or heavy alcohol consumption is a risk factor for oral cancer, esophageal cancer, breast cancer, colorectal cancer, and liver cancer (NCI, 2015). In the respiratory tract and the upper digestive tract, 25-68% of cancers are attributable to alcohol (La Vecchia, Tavani, Franceschi, Levi, Corrao, & Negri, 1997). Smoking and alcohol together have a synergistic effect on cancer risk (Pelucchi, Gallus, Garavello, Bosetti, & La Vecchia, 2006). Up to 80% of cancers in the respiratory tract and the upper digestive tract can be prevented by abstaining from smoking and alcohol (La Vecchia et al., 1997). According to the results from the 2010 National Survey on Drug Use and Health (US Department of Health and Human Services, 2011), Asian Americans had lower current alcohol use and lowest binge and heavy alcohol use. Alcohol

use among detailed Asian subgroups are strongly affected by ethnic drinking cultures and conditioned by the degree of integration into the ethnic cultures (Cook, Mulia, & Karriker-Jaffe, 2012). Among the major six Asian subgroups, Asian Indians and Vietnamese consumed the smallest volume of alcohol, followed by Filipinos and Chinese. Koreans consumed the largest volume of alcohol, followed by Japanese (WHO, 2004b).

Other

Environmental pollution has been linked to various cancers (Anand et al., 2008). Exposure to indoor and/or outdoor air pollutants and carcinogen-contaminated foods can increase the risk for lung cancer, leukemia, lymphoma, colorectal cancer, etc. Radiation is another important risk factor for cancer, particularly for skin cancer and melanoma. These risk factors are associated with living and working conditions (mostly predicted by SES), which also vary among detailed Asian subgroups (Pew Research Center, 2013)

Cancer is a largely preventable disease. Thanks to continued advances in cancer detection and treatment as well as remarkable public health initiatives, cancer incidence and death rates in the US continue to go down (Jemal et al., 2008; Edward et al., 2013; Kohler et al. 2015). According to the Annual Report to the Nation on the Status of Cancer, 1975-2010, from 2001 through 2010, the incidence rates decreased by averagely 0.6% per year among men and remained the same for women, while death rates decreased by averagely 1.8% per year among men and 1.4% per year among women (Edward et al., 2013). However, not all Americans are benefiting equally (CDC, 2014b), which necessitates further research on cancer incidence and survival disparities to identify populations who are disproportionately affected by cancer.

US Asian Americans

According to the US Office of Management and Budget, Asian American is defined as a person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent (US Census, 2012a). In 2010, Asian Americans accounted for 5.6% (17.3 million) of the total US population and constituted the fastest growing racial/ethnic group in the US.

The US Asian American population is comprised of many detailed Asian subgroups originating from over 50 different countries (Pew Research Center, 2013). Currently, in the US, the six largest Asian subgroups are Chinese, Filipino, Asian Indian, Vietnamese, Korean, and Japanese, altogether composed 88.7% of Asian Americans in 2010 (Table 3).

Table 3. The 20 largest US Asian subgroups by origin, 2010*

Rank	Asian subgroup	Population	Percentage
1	Chinese**	4,010,114	23.15%
2	Filipino	3,416,840	19.73%
3	Asian Indian	3,183,063	18.38%
4	Vietnamese	1,737,433	10.03%
5	Korean	1,706,822	9.85%
6	Japanese	1,304,286	7.53%
7	Pakistani	409,163	2.36%
8	Cambodian	276,667	1.60%
9	Hmong	260,073	1.50%
10	Thai	237,583	1.37%
11	Laotian	232,130	1.34%
12	Bangladeshi	147,300	0.85%
13	Burmese	100,200	0.58%
14	Indonesian	95,270	0.55%
15	Nepalese	59,490	0.34%
16	Sri Lankan	45,381	0.26%
17	Malaysian	26,179	0.15%
18	Bhutanese	19,439	0.11%
19	Mongolian	18,344	0.11%
20	Okinawan	11,326	0.07%
Total		17,320,856	

* All Asians include mixed-race and mixed-group populations, regardless of Hispanic origin. There is some overlap among groups
** Includes 215,441 Taiwanese
Source: The Asian Population: 2010, US Census Bureau

Each Asian subgroup is distinctively heterogeneous because of its unique cultural background, language, religious belief, economic and demographic trait, social and political value, and immigration history. These attributes either inherited from country of origin or acquired in the US profoundly shape Asian immigrants' lifestyles and alter their risks for cancer. Many interrelated factors contribute to the health disparities in cancer incidence and survival. A close look at these factors is essential to understand cancer health disparities among US Asian Americans.

Nativity

The US is a nation of immigrants. Following the adoption of the Immigration and Nationality Act of 1965, immigration has been a major source of population growth. According to the Census (Figure 2), Asians accounted for 28% of the total foreign-born population in the US in 2010.

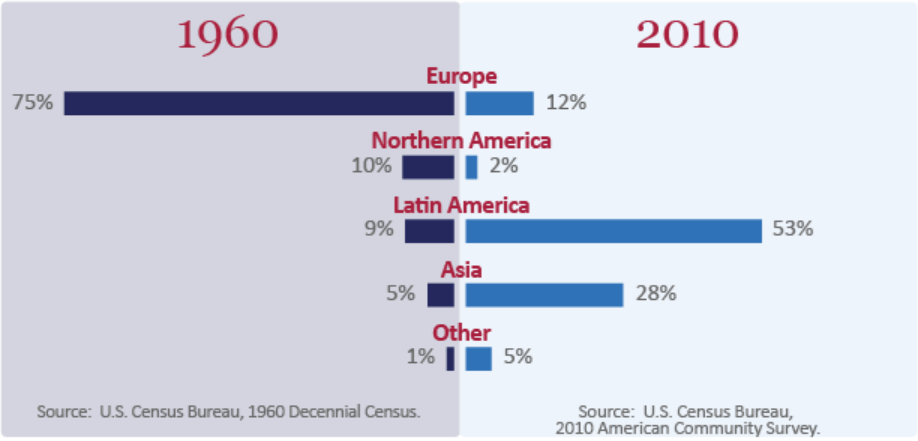


Figure 2. Change in foreign-born population by region of birth

In 2010, 74.1% of US Asian Americans were foreign-born and 28.8% of them immigrated within the past decade (Table 4) (Pew Research Center, 2013). The rates of foreign-born were relatively consistent across detailed Asian subgroups with only one exception of Japanese in 2010.

Table 4. Characteristics of US Asian adults by origin, 2010* ***% (unless otherwise noted)***

	US Total	Asian Total	Chinese	Filipino	Indian	Vietnamese	Korean	Japanese
Foreign born	15.8	74.1	76.2	69.1	87.2	83.7	78.5	31.8
Of these, arrived in past 10 years	26.3	28.8	29.3	24.5	37.6	18.7	24.3	34.1
Median age (in years)	45.0	41.0	43.0	43.0	37.0	41.0	40.0	47.0
Married	51.4	59.0	59.2	56.3	70.9	57.0	55.7	52.7
Educational attainment** (ages 25+)								
Less than high school	14.4	13.9	18.0	7.7	9.2	29.7	7.7	4.8
High school or more	85.6	86.1	82.0	92.3	90.8	70.3	92.3	95.2
Bachelor's degree or more	28.2	49.0	51.1	47.0	70.0	25.8	52.6	46.1
Median annual personal earnings								
Full-time, year-round workers	$40,000	$48,000	$50,000	$43,000	$65,000	$35,000	$45,000	$54,000
Household annual income								
Median	$49,800	$66,000	$65,050	$75,000	$88,000	$53,400	$50,000	$65,390
Average household size (persons)	2.6	3.1	2.9	3.4	3.1	3.6	2.6	2.4
In poverty	12.8	11.9	13.7	6.2	9.0	14.7	15.1	8.3
Language***								
Speaks English "very well"	90.4	63.5	51.9	77.7	76.2	40.5	54.0	81.8
Region of residence								
Northeast	18.3	20.1	27.4	9.7	31.1	10.1	21.3	8.6
Midwest	21.6	11.3	8.8	8.6	16.8	8.4	11.3	8.0
South	37.0	21.5	15.1	15.8	28.5	32.0	22.8	12.2
West	23.0	47.1	48.7	65.9	23.5	49.4	44.6	71.1

* US Asians include mixed-race and mixed-group populations, regardless of Hispanic origin
** "High school or more" includes those who attained at least a high school diploma or an equivalent, such as a General Education Development (GED) certificate
*** "Speaks English 'very well'" includes those who speak only English at home
Source: Pew Research Center analysis of 2010 American Community Survey, Integrated Public Use Microdata Sample (IPUMS) files

Mass immigration from Japan did not occur until the 1890s when industrialists started to recruit Japanese immigrants because Chinese immigrants were barred from entry due to the Chinese Exclusion Act of 1882 (Pew Research Center, 2013). Although Japanese Americans were the largest US Asian subgroup from 1910 to 1960, the immigration flow plummeted as a result of the World War II and rising living standards in Japan. Consequently, Japanese Americans had older median age than the other Asian subgroups (Table 4) as well as more cancer cases (Miller et al., 2007; Gomez et al., 2013).

Nativity, as an indicator for immigration status and acculturation, has been an important factor affecting cancer incidence and survival among Asian Americans (Ladabaum et al., 2014; Chang et al., 2010; Raz et al., 2008; Gomez, Kelsey, Glaser, Lee, & Sidney, 2004). The second-generation Asian Americans are more acculturated than their parents, carrying a cancer profile approaching to that of non-Hispanic whites while blurring the cancer health disparities among Asian Americans (Gomez et al., 2010). However, the confounding effects from US-born Asian Americans is very limited, as least for several decades from now, because the median age of the second-generation Asians was just 17 years old in 2010 (Pew Research Center, 2013), far below 70 years old, the average age at the time of cancer diagnosis (Haselkorn et al., 2015; American Cancer Society, 2016). In addition, the pace of new immigrants from Asia is faster than that of the second-generation Asians stride into "cancer age". According to Statistical Portrait of the Foreign-Born Population in the US, 2012, the proportion of foreign-born Asians will be higher when the current US-born Asians reach their 70s (Pew Research Center, 2014).

Education attainment

Traditional Asian culture put especial value on education. Regardless of the debate of Asian parenting and educational approach, Asian Americans have higher educational attainment and more academic success than the national average, particularly in higher education. Findings from the 2010 American Community Survey showed that 49% of Asian Americans had at least a Bachelor's degree compared with 28% of the US total population (Table 4). Yet, Vietnamese was the only Asian subgroup having lower educational attainment than the US share at all three educational levels. Noteworthy, Asian Indians had the highest educational attainment, 70% of them had at least a Bachelor's degree, approximately 20% higher than the second place Korean. Educational attainment is remarkably higher among recent Asian immigrants. Among those who

entered the US between 2007 and 2010, 61% of them held at least a Bachelor's degree (Pew Research Center, 2013). English proficiency among Asian Americans had a similar pattern to their educational attainment (Table 4). Vietnamese had the lowest English proficiency, followed by Chinese and Koreans. Japanese had the highest English proficiency mostly because of a lower proportion of foreign-born. Individuals' education attainment contributes to their socioeconomic status and shapes their knowledge and attitude towards cancer prevention and screening (CDC, 2012b).

Income

Due to higher educational attainment and favored employment and occupational patterns, the average personal income and household income among Asian Americans were higher than the US shares (Table 4). Again, Vietnamese was the only Asian subgroup with an annual personal income below the national average, although the annual household income was higher than the US share due to a larger household size among Asian Americans. According to the Survey of Income and Program Participation, median household wealth for Asian Americans was $83,500 in 2010, higher than the national average of $68,529 (Pew Research Center, 2013). Nevertheless, Asian-American wealth is not uniformly distributed among Asian subgroups. In 2010, Chinese (13.7%), Vietnamese (14.7%), and Koreans (15.1%) were more likely to live below the poverty line than the US baseline (12.8%) while Filipinos (6.2%) and Asian Indians (9.0%) were less likely to be poor (Pew Research Center, 2013). Noticeable economic inequality partitions Asian Americans into different levels of socioeconomic status, contributing to cancer health disparities among specific Asian subgroups.

Region of residence

In the 2010 Census, 46% of Asian Americans lived in the West, 22% in the South, 20% in the Northeast, and 12% in the Midwest (Figure 3). The findings from the American Community Survey in 2010 showed identical distribution (Table 4). Residential settlement patterns varied greatly among Asian subgroups. Japanese (71%) and Filipinos (66%) were more likely to live in the West, where was home to approximately half of Chinese, Vietnamese, and Koreans as well. Asian Indians had more even distribution around the county. Unlike the other Asian subgroups, the two largest shares of Asian Indians lived in the Northeast (31%) and South (29%). Region of residence has been linked with variations observed in cancer incidence and survival (Laden et al., 1997; CDC, 2015), partially due to differences in local health care quality and costs (Newhouse & Garber, 2013).

The geographic variations, to some extent, also affect cancer research on racial disparities among Asian Americans. SEER covers approximately 50% of the US Asian Americans but 73.2% of them reside in the West, mostly in California. Therefore, data from the other quality cancer registries where large Asian American population reside, such as Texas, New York, Florida, Washington, and Illinois, will be a valuable addition to increase diversity of Asian Americans and coverage of Asian Indians. Moreover, immigrants and ethnic minorities are prone to live in ethnic enclaves with high proportions of residents from the same ethnic group (Osypuk, Diez Roux, Hadley, & Kandula, 2009). Their cancer profiles will be approximate because of similar lifestyles and SES (Keegan et al., 2010). Hence, a geographic region is a dynamic unit depending on the total population size and distribution of Asian subgroups. A small unit, such as county, sometimes is preferred to examine cancer health disparities among Asian Americans.

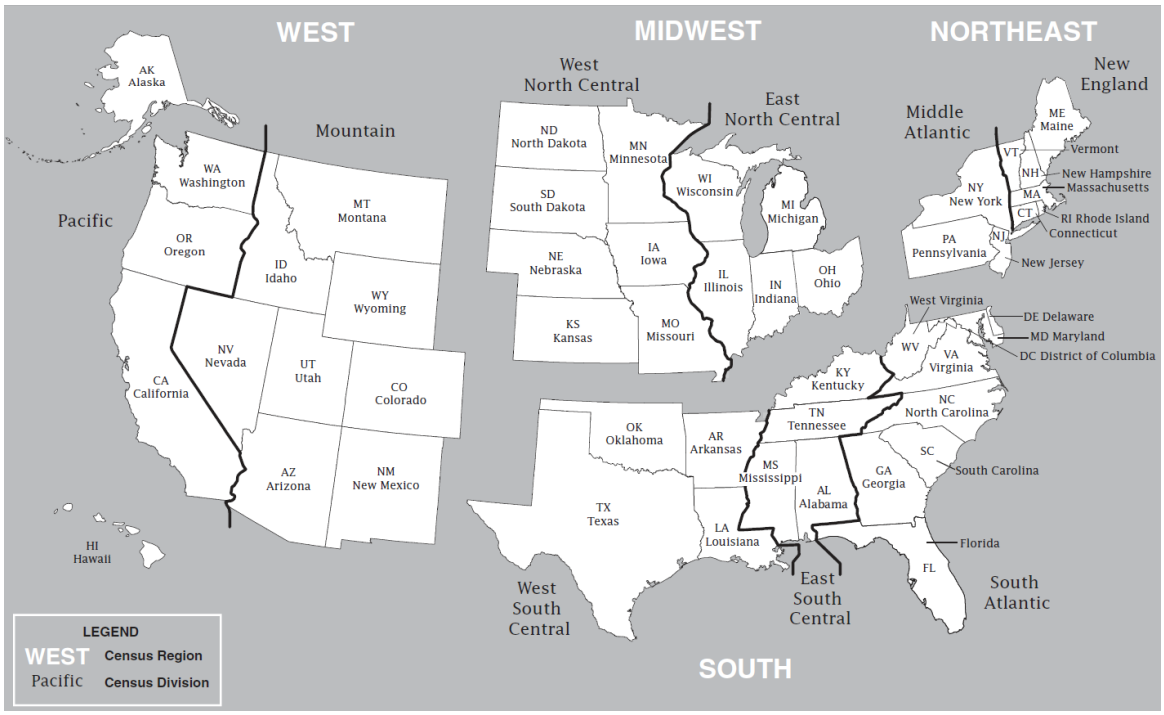


Figure 3. Map of the United States, showing census regions and divisions; Source: US Census Bureau

Despite the diversity and heterogeneity of specific Asian subgroups, dominant cancer research literature tends to aggregate Asian subgroups into one large group or combine with Pacific Islanders. The most current national cancer reports – the Annual Report to the Nation on the Status of Cancer 1975-2011 (Kohlers et al., 2015) and the United States Cancer Statistics 1999-2009 Cancer Incidence and Mortality Data – disappointedly adopted "Asian and Pacific Islander" to address cancer burdens among Asian Americans. However, the model minority stereotype and above-average cancer statistic obscure cancer health disparities and unmet public health needs among specific Asian subgroups.

Research on Cancer Health Disparities among Asian Americans

Overcoming cancer health disparities is one of the keystones to reduce the burden of cancer in the US. While cardiovascular disease holds the leading cause of death in the US for decades, cancer has been the number one killer among Asian Americans (Gomez et al., 2014). However, research on cancer health disparities among Asian subgroups has been hampered due to the complexity and difficulty in collecting data on race/ethnicity by cancer registries.

Population-based cancer registries in the US

Since the first cancer registry established at Yale-New Haven Hospital in 1926, population-based cancer registries possesses a vital role in advancing cancer research and revealing cancer health disparities in the US Today, the National Program of Cancer Registries (NPCR) of the CDC and the SEER Program of the NCI, altogether covering the entire US, provide information on cancer statistics in an effort to reduce the burden of cancer among the US population. The NAACCR, working with CDC and NCI together, establishes guidelines for all state registries to achieve compatible cancer data. The US population has experienced drastic increases in racial/ethnic diversity over the last several decades due to immigration waves from Latin American and Asia. However, the accuracy and completeness of cancer registry data on race/ethnicity have been challenged by limited resources.

Population-based cancer registries obtain race/ethnicity data primarily from medical records. Partially caused by inconsistent hospital policies and practices on collecting race/ethnicity data (Gomez, Le, West, Satariano, & O'Connor, 2003), misclassification was moderate for Asians but varied by Asian subgroup (Gomez & Glaser, 2006). In the on-going efforts to enhance

identification of detailed Asian subgroups, the NAPIIA was developed (Hsieh, Pareti, & Chen, 2011) but has never been officially adopted by SEER or NPCR.

Another notable problem is the presence of Asian, not otherwise specified (NOS) in cancer registry data, a category to which an Asian cancer case with unknown Asian subgroup is assigned. With the rapid growth of Asian American population, the proportions of NOS have been steadily rising over the last several decades. In SEER, the proportion increased from 1.2% in 1990 to 10.6% in 2008 (Gomez et al., 2013) and reached 11.7% between 2009 and 2011. In NPCR, the proportion of Asian, NOS is higher because of relatively lower data completeness. For example, approximately 40% of Asian cases in Texas diagnosed between 2009 and 2011 were classified as NOS. Currently, the most common method to treat this problem is pairwise deletion because NOS cannot be included in any specific Asian subgroup (Miller et al., 2007; Gomez et al., 2013). However, incidence rates for specific Asian subgroups might be underestimated because of exclusion of these cases.

The majority of cancer researchers favored SEER data due to its reputation for accuracy, completeness, and convenience, although it covers only approximately 50% of Asians in the US. However, Asian Indians are relatively under-represented (39.4%) in SEER than the other Asian subgroups (Table 5).

Table 5. Population estimates by Asian subgroup in SEER and the US, 2010*

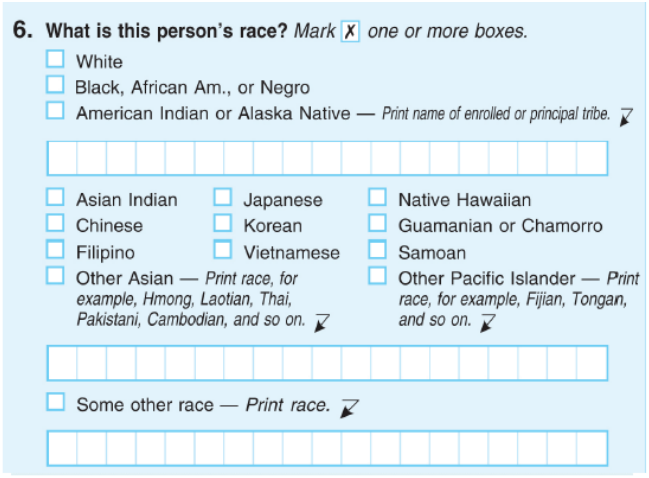
Asian subgroup	SEER Population	US Population	Percentage
Chinese**	1,671,391	3,347,229	49.9
Filipino	1,657,524	2,555,923	64.9
Asian Indian	1,121,539	2,843,391	39.4
Vietnamese	786,540	1,548,449	50.8
Korean	720,344	1,423,784	50.6
Japanese	534,808	763,325	70.1

*Race-specific counts and percentages in this table are based on persons self-reporting only one race
Source: US Bureau of Census, Census 2010, Summary File 2

Therefore, using SEER's population bases solely may not be able to provide a robust assessment on cancer health disparities in Asian Americans, particularly in Asian Indians. The addition of NPCR data is valuable to increase diversity of Asian Americans and coverage of Asian Indians.

Population estimates

National data on cancer incidence and survival for detailed Asian subgroups are not routinely available due to lack of accurate population estimates for Asian subgroups (McCracken et al., 2007). The decennial US Census provides the most accurate population estimates for most cancer research. The 2010 US Census question on race included seven separate response categories of Asian subgroups and one area where respondents could write in detailed Asian subgroups not listed, which allows each respondent to report multiple races (Figure 4).



Source: U.S. Census Bureau, 2010 Census questionnaire.

Figure 4. Reproduction of the question on race from the 2010 Census

First, people who report only one detailed Asian subgroup, such as "Asian Indian", are referred to as "Asian alone with only one detailed Asian subgroup reported" (Figure 5). Respondents who

report more than one detailed Asian subgroup, such as "Chinese and Filipino", are referred to as "Asian alone with two or more detailed Asian subgroups reported". But each detailed Asian subgroup will be counted once separately. Second, respondents who report one or more Asian subgroup and one or more non-Asian race, such as "Chinese and Hawaiian", or "Chinese, Filipino, Hawaiian, and White", are referred to as "Asian in combination with one detailed Asian subgroup reported" or "Asian in combination with two or more detailed Asian subgroups reported". Cancer in multiracial Asian Americans is an emerging and important topic in cancer research because the blend of cultures and lifestyles complicate cancer risk factors and alter their cancer profiles. However, this topic is beyond the scope of the present study. Also, multiracial Asian Americans are more likely to be the second-generation Asian immigrants after interracial marriage occurs. Therefore, they are young and the least likely group to develop cancer (Pew Research Center, 2013).

Asian Population by Number of Detailed Groups: 2010

(For information on confidentiality protection, nonsampling error, and definitions, see *www.census.gov/prod/cen2010/doc/sf1.pdf*)

Detailed group	Asian alone		Asian in combination with one or more other races		
	One detailed Asian group reported	Two or more detailed Asian groups reported[1]	One detailed Asian group reported	Two or more detailed Asian groups reported[1]	Detailed Asian group alone or in any combination[1]
Total	[2]14,327,580	346,672	2,429,530	217,074	17,320,856
Asian Indian	2,843,391	75,416	240,547	23,709	3,183,063
Bangladeshi	128,792	13,288	4,364	856	147,300
Bhutanese	15,290	3,524	442	183	19,439
Burmese	91,085	4,451	4,077	587	100,200
Cambodian	231,616	23,881	18,229	2,941	276,667
Chinese[3]	3,347,229	188,153	334,144	140,588	4,010,114

Figure 5. Asian population by detailed group from the 2010 Census

In order to produce population estimates for specific Asian subgroups, the two Asian alone categories have to be added up together. Gomez et al. (2013) adopted the mean of Asian alone and Asian alone or in combination for each detailed Asian subgroup. Because each reported Asian

subgroup in "Asian alone or in combination with two or more detailed Asian subgroups reported" will be counted once separately, averaging the two groups will introduce repeated cases to the population estimates. For example, only 346,672 respondents self-identified as Asian with two or more detailed groups (Table 6). However, 709,212 cases were counted from this group, resulting in an inflated population estimate by 2.5% and consequent underestimated rates. New method is required to bridge population estimate by adjusting for repeated cases.

Table 6. Asian population by detailed groups, 2010

Asian subgroup	Asian Alone	
	One detailed group	Two or more detailed groups
Chinese	3,347,229	188,153
Filipino	2,555,923	94,050
Asian Indian	2,843,391	75,416
Vietnamese	1,548,449	84,268
Korean	1,423,784	39,690
Japanese	763,325	78,499
Other Asian	1,845,479	149,136
Total	14,327,580	709,212
Net Total	14,327,580	346,672

Source: US Bureau of Census, Census 2010, Summary File 1

Since the US Census is only available every 10 years. Statistical methods, such as linear interpolation and extrapolation, are adopted to project population estimates for intercensal years and postcensal years (Kwong et al., 2005; Gomez et al., 2013). These methods assume that population growth is constant, in spite of the fact that the growth rates are changing all the time and vary greatly by race/ethnicity. Therefore, cancer rates based on projected population estimates are not accurate.

Cancer incidence disparities among Asian Americans

Asians have lower overall incidence compared to the national average, but they have higher rates of cancers related to infectious agents and rising rates of cancers related to lifestyles (Kwong

et al., 2005; McCracken et al., 2007; Miller et al., 2007; Gomez et al., 2013). Model minority stereotype masks the urgent needs in cancer prevention and screening among US Asian Americans, resulting in widening cancer health disparities among specific Asian subgroups.

Currently, only two recent literatures systematically examined cancer incidence disparities among Asian subgroups. Gomez et al. (2013) investigated national cancer trends for specific Asian subgroups using 1990-2008 SEER data, which provides valuable baseline data for the present study (Table 7, 8). Miller et al. (2007) examined cancer incidence and mortality patterns among specific Asian and Pacific Islander population using 1998-2002 (Table 9, 10). Incidence rates from the two articles are both reported in Table 7-10. Given the identical patterns and similar rates, results from Gomez et al. are discussed mostly due to newer data.

Table 7. Age-adjusted incidence rates by Asian subgroup and non-Hispanic white, men, 2004-2008

Race	All sites	Prostate	Lung	Colon/rectum	Liver	Stomach
Chinese	320.9	74.9	52.0	42.1	24.1	16.3
Filipino	385.1	117.2	68.4	47.8	17.1	-
Asian Indian and Pakistani	283.6	84.3	30.1	23.4	-	-
Vietnamese	367.5	56.0	73.4	41.1	58.5	21.2
Korean	400.0	63.5	57.5	58.2	34.9	52.5
Japanese	403.9	109.5	52.4	66.6	-	24.2
Non-Hispanic white	560.2	154.7	74.0	54.0	-	-

Incidence rate: annual cases per 100,000 persons. Age adjusted to the 2000 US standard population Source: Gomez et al., 2013

Table 8. Age-adjusted incidence rates by Asian subgroup and non-Hispanic white, women, 2004-2008

Race	All sites	Breast	Lung	Colon/rectum	Uterine	Thyroid
Chinese	263.3	78.8	29.9	35.7	14.3	12.2
Filipino	312.2	103.7	30.1	31.8	22.0	21.4
Asian Indian and Pakistani	250.1	88.3	12.4	18.8	16.4	11.9
Vietnamese	285.7	63.0	31.8	35.8	-	15.1
Korean	290.6	69.5	28.0	40.9	-	15.3
Japanese	307.5	104.9	27.9	43.0	20.0	-
Non-Hispanic white	440.0	135.3	56.6	40.6	26.2	-

Incidence rate: annual cases per 100,000 persons. Age adjusted to the 2000 US standard population. Source: Gomez et al., 2013

Table 9. Age-adjusted incidence rates by Asian subgroup and non-Hispanic white, men, 1998-2002

Race	All sites	Prostate	Lung	Colon/rectum	Liver	Stomach
Chinese	348.8	84.8	53.0	54.0	24.0	18.3
Filipino	393.2	121.9	72.5	50.4	17.2	-
Asian Indian and Pakistani	292.1	98.4	30.8	23.1	-	-
Vietnamese	374.3	59.1	72.3	41.2	55.5	25.6
Korean	372.6	55.7	61.1	55.9	35.9	55.0
Japanese	422.4	115.0	49.8	75.9	-	29.3
Non-Hispanic white	587.0	170.0	89.2	65.6	-	-

Incidence rate: annual cases per 100,000 persons. Age adjusted to the 2000 US standard population Source: Miller et al., 2007

Table 10. Age-adjusted incidence rates by Asian subgroup and non-Hispanic white, women, 1998-2002

Race	All sites	Breast	Lung	Colon/rectum	Endometriu	Thyroid
Chinese	270.4	77.6	29.7	40.2	12.0	-
Filipino	291.1	100.4	26.0	29.4	18.6	17.7
Asian Indian and Pakistani	238.1	82.1	13.1	18.8	13.5	-
Vietnamese	270.6	52.8	34.4	33.3	16.8	-
Korean	254.5	53.5	27.5	35.9	-	-
Japanese	342.4	126.5	24.7	51.9	20.4*	-
Non-Hispanic white	448.5	145.2	59.0	47.6	-	-

Incidence rate: annual cases per 100,000 persons. Age adjusted to the 2000 US standard population. Source: Miller et al., 2007
*For Vietnamese, incidence rate for cervix and uteri was estimated instead of endometrium

Prostate cancer was the most common cancer for Asian American men except for Vietnamese (Table 7, 9). The rates varied two-fold across the major six Asian subgroups. Filipino and Japanese men had the highest rates, which were approximately 25% lower than non-Hispanic whites. Lung cancer was the most common cancer among Vietnamese men with a comparable rate with non-Hispanic whites and the second most common cancer among Chinese, Filipino, Asian Indian and Pakistani men. Japanese and Korean men had highest colorectal cancer rates, which were higher than non-Hispanic whites. Notably, in contrast with non-Hispanic whites, liver cancer and/or stomach cancer were ranked as one of the five most common cancers among all male Asian subgroups except for Asian Indian and Pakistani men. Vietnamese men had the highest liver cancer rate while Korean men were disproportionately affected by stomach cancer.

Breast cancer was the most common cancer for Asian American women (Table 8, 10). Japanese and Filipino women had the highest rates, which were nearly 29% lower than non-Hispanic whites. Colorectal cancer and lung cancer were the second and third most common cancer for Asian American women. Vietnamese women had the highest rates of lung cancer, which were about 44% lower than non-Hispanic whites. Japanese and Korean women had the highest rates of colorectal cancer, which were higher than non-Hispanic whites. Unlike Asian American men, stomach cancer was ranked as one of the five most common cancers among Korean and Japanese women only. Liver cancer was the fourth most common cancer among Vietnamese women only. However, thyroid cancer, which used to less affect Asian American women (Table 10), made the fifth most common cancer for Asian American women with the only exception of Japanese and disproportionately affected Filipino women.

Survival

Cancer survival is a more complex concept than mortality because it takes survival time after diagnosis into account. In spite of sporadic research on cancer survival among Asian Americans, variations in cancer survival have also been found among specific Asian subgroups.

Lin et al. (2002) examined survival difference of prostate, colorectal, breast, and cervical cancer among Chinese, Japanese, and Filipinos using 1988-1994 SEER data. Filipino men were more likely to be diagnosed with advanced stage prostate and colorectal cancer and had lower 5-year survival rate. Chinese women were more likely to be diagnosed with advanced stage colorectal cancer and had lowest 5-year survival rate. Chinese and Filipino women were more likely to be diagnosed with advanced stage breast cancer and had lower 5-year survival rates. Japanese women were less likely to be diagnosed with advanced stage cervical cancer but had

lower survival rate. This article highlighted the importance of stage at diagnosis in predicting cancer survival. Unfortunately, Lin et al. didn't perform multivariate analysis to adjust for other confounding covariates.

Le et al. (2009) analyzed colorectal cancer survival among major Asian subgroups using 1994-2003 California Cancer Registry data. Multivariate analyses were performed to detect racial disparities among Asian subgroups. After adjustment for age, gender, grade, histology, site within the colon, stage of diagnosis, insurance status, socioeconomic status, and treatment, only Filipino and Chinese had significantly decreased risk of death than non-Hispanic whites.

Chang et al. (2009) investigated non–small-cell lung cancer survival among Asian subgroups using 1988-2007 California Cancer Registry data. Asian American and Pacific Islanders demonstrated better overall and disease-specific survival than non-Hispanic whites, but survival varied greatly across Asian subgroups. Among women, Japanese had significantly poorer overall and disease-specific survival than Chinese while South Asian women had significantly better survival than Chinese. Among men, Japanese, Vietnamese had significantly poorer overall and disease-specific survival than Chinese. Besides Asian subgroup, lower neighborhood socioeconomic status, involvement with a non-university hospital, unmarried status, older age, and earlier year of diagnosis significantly predicted poorer survival.

Cancer survival advantages have been found among Asian Americans (Chang et al., 2009; Ou et al., 2009). However, this message might be misleading because cancer survival in Asians are more likely to be overestimated due to more missing deaths resulting from problematic death linkages (Pinheiro, Morris, Liu, Bungum, & Altekruse, 2014). Further research is indispensable

to examine cancer survival disparities among Asian subgroups, especially in cancers disproportionately affecting specific Asian Americans, such as stomach cancer.

Summary

US Asian Americans are bearing heavy burden of cancer. Current research on cancer health disparities among Asian Americans is relatively scarce for this rapidly growth population. The cancer burden in Asian Americans is unique. Cancer is the leading cause of death only among Asian Americans in the US Their cancer burden also is unusual. Asian Americans have higher incidence and mortality rates of cancers of infectious origins. More importantly, their cancer burden is unnecessary. The majority of cancers disproportionately affecting Asian Americans are preventable and/or early-diagnosable by effective vaccination and timely screening.

In the on-going efforts to research cancer health disparities among specific Asian subgroups, the dominant literature is rooted on SEER's population bases and is troubled by underestimated numerators and inflated denominators. Research on survival disparities is scattered and outdated. Current literature misses data on important cancer sites and lacks of systematical comparisons among major Asian subgroups and with racial/ethical majorities. With the newly-released SEER and NPCR data and 2010 US Census, it is imperative to explore cancer health disparities among Asian Americans because representative and accurate estimates in cancer incidence and survival would facilitate priority assessment, better inform public health policies, and improve access to quality healthcare and prevention.

Chapter 3

Cancer Incidence among US Asian American Populations

Introduction

Asian Americans are the fastest growing racial/ethnic group in the United States (US Census, 2012a). 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 (US Census, 2012a). This has been fueled primarily by international immigration from Asia (US Census, 2013). In 2010, 74% of Asian American adults were foreign-born; of those, 36% immigrated in 2000 or later (US Census, 2012b; Pew Research Center, 2013). 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 (Census, 2012a). The heterogeneous Asian American population is comprised of distinct subgroups with differences in genetics, culture, lifestyle, immigration and settlement experiences (Gomez et al., 2014). 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 (Gomez et al., 2014). Some previous studies using population-based cancer registry data have revealed clear differences in cancer incidence among specific Asian subgroups (Cheng et al., 2014; Gomez et al., 2013; Miller et al., 2007; McCracken et al., 2007; Giddings, Kwong, Parikh-Patel, Bates, & Snipes, 2012; Wang et al., 2010; Carreon et al. 2008; Reynolds et al., 2011; Gomez et al., 2010; Liu et al., 2012). 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 (Cheng et al., 2014; Gomez et al., 2013; Miller et al., 2007; McCracken et al., 2007; Giddings, Kwong, Parikh-Patel, Bates, & Snipes, 2012; Wang et al., 2010; Carreon et al. 2008; Reynolds et al., 2011; Gomez et al., 2010; Liu et al., 2012), 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 Purpose

The purpose of this study is to investigate cancer incidence disparities among Asian Americans in the US with pooled cancer registry data from SEER and NPCR.

Research Question

Do cancer incidence disparities exist among specific Asian subgroups?

Hypotheses

Hypothesis 1

H_0: Overall cancer incidence rates do not vary between non-Hispanic whites and Asians from 2009 to 2011

H_A: Overall cancer incidence rates vary between non-Hispanic whites and Asians from 2009 to 2011

Hypothesis 2

H_0: Overall cancer incidence rates do not vary between Asian subgroups from 2009 to 2011

H_A: Overall cancer incidence rates vary between Asian subgroups from 2009 to 2011

Hypothesis 3

H_0: Site-specific cancer incidence rates do not vary between non-Hispanic whites and Asians 2009 to 2011

H_A: Site-specific cancer incidence rates vary between non-Hispanic whites and Asians from 2009 to 2011

Hypothesis 4

H_0: Site-specific cancer incidence rates do not vary between Asian subgroup from 2009 to 2011

H_A: Site-specific cancer incidence rates vary between Asian subgroup from 2009 to 2011

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 11).

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 (Miller et al., 2008). 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 (NAACCR, 2016a). 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 (NAACCR, 2016a). Asians cases reporting non-Asian race(s) except white were excluded because Asian only takes precedence over white in multiracial coding (NAACCR, 2016b). 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 11). 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.

Table 11. 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[§]
	Greater California Registry[*]	Greater California Registry[*]	Orange County
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

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 (Pinheiro et al., 2009).

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:

$$AR_{jlm} = [\sum_{i=4}^{7} (dijlm / Dijlm)] / 4$$

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 (Tiwari, Clegg, & Zou, 2006). 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 12). 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 13 and 14). Within each Asian subgroup, the increment also differed substantially by cancer site.

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

The overall cancer incidence rate for Asian American men was 336.5/100,000 person-years; for women it was 299.6/100,000 (Table 15 and 16). 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.

Table 13. Age adjusted cancer incidence rates before stratified imputation 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	
	Rate	**(95% CI)**	**Rate**	**(95% CI)**	**Rate**	**(95% CI)**	**Rate**	**(95% CI)**	**Rate**	**(95% CI)**	**Rate**	**(95% CI)**	**Rate**	**(95% CI)**	**Rate**	**(95% CI)**
Oral	12.0	(10.9-13.2)	8.2	(7.1-9.4)	10.8	(9.0-12.9)	5.7	(4.4-7.4)	12.8	(11.1-14.6)	9.8	(8.1-11.6)	11.7	(11.1-12.3)	19.0	(18.7-19.2)
Nasopharynx	4.4	(3.8-5.2)	2.9	(2.3-3.7)	0.7	(0.2-1.7)	0.8	(0.4-1.6)	0.8	(0.4-1.5)	4.1	(3.1-5.4)	4.1	(3.8-4.5)	0.6	(0.6-0.7)
Stomach	15.7	(14.4-17.1)	7.4	(6.3-8.6)	16.9	(14.8-19.4)	35.0	(31.4-39.0)	7.2	(5.9-8.6)	13.9	(11.6-16.6)	15.9	(15.2-16.7)	8.2	(8.0-8.3)
Colorectal	36.7	(34.7-38.8)	41.8	(39.2-44.6)	54.8	(50.7-59.2)	42.5	(38.5-46.8)	23.7	(21.2-26.3)	39.0	(35.3-43.1)	43.1	(41.9-44.3)	47.5	(47.1-47.8)
Liver	20.9	(19.4-22.4)	16.2	(14.6-18.0)	13.1	(11.2-15.3)	23.8	(21.0-27.0)	8.9	(7.5-10.4)	48.0	(44.0-52.3)	22.4	(21.6-23.2)	10.1	(9.9-10.3)
Pancreas	9.8	(8.8-10.9)	9.8	(8.6-11.2)	13.9	(11.9-16.2)	11.4	(9.3-13.8)	7.1	(5.7-8.7)	9.5	(7.7-11.6)	10.8	(10.2-11.5)	14.6	(14.3-14.8)
Lung	47.4	(45.1-49.8)	58.2	(55.0-61.6)	42.6	(39.1-46.4)	40.6	(36.5-45.0)	24.0	(21.5-26.8)	59.6	(54.8-64.7)	49.6	(48.3-51.0)	75.3	(74.8-75.8)
Prostate	53.2	(50.8-55.6)	90.0	(86.1-93.9)	82.1	(77.1-87.3)	41.1	(37.2-45.3)	62.3	(58.5-66.3)	41.2	(37.3-45.3)	74.5	(72.9-76.1)	130.2	(129.6-130.8)
Bladder	13.3	(12.1-14.6)	10.5	(9.2-12.1)	19.4	(17.1-22.0)	19.2	(16.4-22.3)	13.6	(11.7-15.7)	8.0	(6.3-10.1)	15.8	(15.1-16.6)	41.4	(41.0-41.7)
Kidney	8.5	(7.6-9.6)	13.5	(12.1-15.1)	14.2	(12.1-16.7)	10.9	(8.9-13.2)	9.3	(7.9-10.8)	7.2	(5.7-9.0)	12.0	(11.4-12.6)	22.2	(21.9-22.4)
Thyroid	5.9	(5.2-6.8)	8.2	(7.1-9.4)	3.3	(2.3-4.6)	6.8	(5.4-8.5)	4.5	(3.7-5.4)	4.1	(3.0-5.4)	6.8	(6.4-7.3)	8.1	(7.9-8.3)
NHL	14.0	(12.8-15.3)	18.0	(16.3-19.9)	15.3	(13.1-17.8)	10.2	(8.3-12.4)	15.5	(13.5-17.7)	14.4	(12.2-17.0)	16.7	(16.0-17.5)	25.2	(25.0-25.5)
Leukemia	6.9	(6.1-7.9)	10.7	(9.3-12.2	9.7	(7.9-11.9)	7.1	(5.6-9.0)	11.4	(9.8-13.3)	12.6	(10.5-15.0)	10.5	(9.9-11.1)	18.6	(18.4-18.9)
Other-sites combined	35.1	(33.2-37.2)	41.7	(39.0-44.4)	45.2	(41.3-49.5)	41.1	(37.1-45.4)	47.4	(44.0-51.0)	41.1	(37.1-45.3)	46.6	(45.4-47.9)	121.7	(121.1-122.3)
All-sites combined	279.5	(274.0-285.1)	334.2	(326.7-341.9)	341.5	(331.1-352.1)	295.5	(284.7-306.5)	247.7	(239.8-255.7)	308.4	(297.6-319.5)	336.5	(333.1-339.8)	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

Table 14. Age adjusted cancer incidence rates before stratified imputation 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	
	Rate	**(95% CI)**	**Rate**	**(95% CI)**	**Rate**	**(95% CI)**	**Rate**	**(95% CI)**	**Rate**	**(95% CI)**	**Rate**	**(95% CI)**	**Rate**	**(95% CI)**	**Rate**	**(95% CI)**
Oral	5.2	(4.6-6.0)	3.4	(2.9-4.1)	3.9	(3.0-5.0)	1.9	(1.2-2.7)	5.4	(4.4-6.6)	4.7	(3.6-6.1)	4.9	(4.6-5.3)	7.0	(6.9-7.2)
Nasopharynx	1.7	(1.3-2.2)	0.9	(0.7-1.3)	0.4	(0.2-1.0)	0.3	(0.1-0.7)	0.4	(0.1-0.9)	1.7	(1.1-2.6)	1.3	(1.1-1.5)	0.2	(0.2-0.3)
Stomach	8.3	(7.4-9.2)	4.1	(3.4-4.8)	10.0	(8.7-11.6)	17.1	(15.1-19.4)	4.5	(3.5-5.6)	9.7	(8.0-11.7)	8.9	(8.4-9.4)	3.7	(3.6-3.8)
Colorectal	27.4	(25.8-29.0)	28.3	(26.6-30.1)	37.5	(34.7-40.5)	30.0	(27.3-32.9)	17.7	(15.7-19.9)	28.0	(25.1-31.1)	31.6	(30.7-32.5)	36.5	(36.2-36.8)
Liver	7.5	(6.7-8.4)	5.5	(4.7-6.3)	6.8	(5.7-8.1)	9.1	(7.6-10.8)	4.1	(3.2-5.1)	13.4	(11.3-15.8)	8.1	(7.6-8.6)	3.4	(3.3-3.5)
Pancreas	7.2	(6.4-8.0)	8.5	(7.5-9.5)	11.7	(10.3-13.5)	9.1	(7.6-10.8)	5.0	(3.9-6.2)	7.3	(5.8-9.2)	9.0	(8.6-9.5)	10.9	(10.8-11.1)
Lung	28.4	(26.8-30.1)	26.8	(25.1-28.5)	28.2	(25.9-30.8)	24.9	(22.4-27.6)	12.7	(11.0-14.6)	28.2	(25.2-31.4)	28.6	(27.8-29.5)	59.4	(59.0-59.8)
Breast	70.3	(67.8-72.8)	95.2	(92.2-98.3)	114.1	(108.7-119.8)	63.8	(60.0-67.8)	85.3	(81.4-89.4)	56.4	(52.6-60.3)	94.5	(93.0-96.0)	134.4	(133.8-135.1)
Premenopausal	24.1	(22.7-25.7)	27.9	(26.2-29.7)	37.3	(33.8-41.2)	23.5	(21.3-26.0)	24.5	(22.7-26.3)	20.4	(18.3-22.7)	30.1	(29.3-31.0))	34.3	(33.9-34.6)
Postmenopausal	46.1	(44.1-48.1)	67.3	(64.8-69.9)	76.8	(72.7-81.1)	40.3	(37.3-43.4)	60.9	(57.4-64.6)	36.0	(32.9-39.3)	64.4	(63.2-65.6)	100.2	(99.7-100.7)
Cervix Uteri	4.9	(4.3-5.6)	6.3	(5.5-7.1)	5.7	(4.5-7.3)	6.2	(5.1-7.6)	4.6	(3.7-5.6)	7.7	(6.2-9.3)	6.5	(6.1-6.9)	7.5	(7.3-7.6)
Corpus and uterus	13.0	(12.0-14.1)	22.0	(20.5-23.5)	20.7	(18.4-23.1)	7.8	(6.5-9.3)	17.6	(15.8-19.6)	10.9	(9.3-12.7)	18.7	(18.0-19.3)	26.6	(26.3-26.9)
Ovary	7.7	(6.9-8.6)	8.7	(7.7-9.7)	7.5	(6.1-9.1)	7.2	(6.0-8.7)	10.9	(9.5-12.5)	8.2	(6.7-9.9)	9.7	(9.3-10.2)	13.1	(12.9-13.3)
Bladder	3.9	(3.4-4.6)	2.4	(1.9-3.0)	4.6	(3.7-5.7)	2.5	(1.8-3.6)	4.1	(3.1-5.3)	2.2	(1.4-3.2)	3.9	(3.6-4.2)	10.3	(10.1-10.4)
Kidney	4.2	(3.6-4.8)	5.1	(4.4-5.9)	5.4	(4.3-6.7)	3.6	(2.7-4.8)	4.5	(3.6-5.6)	3.7	(2.7-4.9)	5.3	(4.9-5.6)	11.1	(11.0-11.3)
Thyroid	16.8	(15.6-18.1)	23.5	(22.0-25.2)	9.7	(8.0-11.7)	18.2	(16.2-20.4)	14.3	(12.9-15.8)	14.3	(12.5-16.4)	21.5	(20.8-22.2)	22.4	(22.1-22.7)
NHL	9.0	(8.1-9.9)	12.3	(11.2-13.6)	10.9	(9.4-12.6)	7.1	(5.8-8.6)	9.7	(8.2-11.3)	9.7	(8.0-11.6)	11.7	(11.2-12.3)	17.3	(17.0-17.5)
Leukemia	4.8	(4.1-5.5)	7.0	(6.1-7.9)	6.0	(4.5-7.7)	3.3	(2.4-4.4)	7.0	(5.8-8.3)	6.4	(5.1-8.0)	6.5	(6.1-6.9)	11.4	(11.2-11.5)
Other-sites combined	23.5	(22.0-25.0)	26.3	(24.6-28.0)	28.1	(25.3-31.2)	25.2	(22.6-28.0)	33.2	(30.5-36.2)	28.4	(25.5-31.6)	30.3	(29.4-31.2)	74.2	(73.8-74.7)
All-sites combined	242.1	(237.4-246.8)	285.3	(279.9-290.8)	310.8	(302.0-319.8)	237.2	(229.5-245.0)	240.6	(233.6-247.8)	239.1	(230.7-247.8)	299.6	(296.9-302.3)	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

Table 15. 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 16. 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

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 (Gomez et al., 2013; Miller et al., 2008; McCracken et al., 2007), 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 (Gomez et al., 2013; Miller et al., 2008; McCracken et al., 2007) but in Western countries like the US incidence is mostly driven by the extent of prostate-specific antigen (PSA) screening coverage (Delfino, Ferrini, Taylor, Howe, & Anton-Culver, 1998), 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 (California Health Interview Survey, 2015). 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 (Matias & Raymundo, 2014). These products are popular in traditional Asian diets and have been associated with a 25%-30% reduced risk for prostate cancer (Hwang, Kim, Jee, Kim, & Nam, 2009; Yan & Spitznagel, 2009).

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 (US Census, 2012b). 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 (Reynolds et al., 2011; Gomez et al., 2010; Liu et al., 2012). 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 (California Health Interview Survey, 2015), which are prevalent risk factors for breast cancer in Western populations (Kelsey, Gammon, & John, 1993; Lambe et al., 1996). 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 (California Health Interview Survey, 2015). 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 (US Census, 2012b), 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 (California Health Interview Survey, 2015; Gingras & Béliveau, 2011). 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 (Kuriki & Tajima, 2006). 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, 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 (Ferlay et al., 2012). 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 (Destura et al., 2004; World Gastroenterology Organization,

2010). 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 (Kim, 2003; Wang, Terry, & Yan, 2009).

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 (Nguyen & Keeffe, 2003), which may partially be attributed to the absence of newborn hepatitis B vaccination in Vietnam until 2012 (Nguyen, Law, & Dore, 2008). Moreover, the 6% prevalence of HCV infection in Vietnam is high compared to the average prevalence of 2% for most other Asian countries (Nguyen & Keeffe, 2003). 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 (Nguyen & Keeffe, 2003). 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 (Puri, 2014; Dhiman, 2014). 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 (Tandon, Acharya, & Tandon, 1996; Mukhopadhya, 2008). 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

(California Health Interview Survey, 2015), 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 (Thompson & Kurzrock, 2004). 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 (Li, Fasano, Wang, Yao, & Marincola, 2009; Chang & Adami, 2006). 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) (Ferlay et al., 2012). The first generation of Chinese Americans came mainly from China's Guangdong Province where nasopharyngeal carcinoma rates are much higher than in other provinces (Cao, Simons, & Qian, 2011). Moreover, nasopharyngeal cancer is known to occur with obvious familial aggregation (Cao et al., 2011). 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 (California Health Interview Survey, 2015). Low English

proficiency, low educational attachment, and high poverty rates among Vietnamese women may adversely impact their receipt of assistance with cervical cancer control (Taylor, Nguyen, Jackson, & McPhee, 2008; California Health Interview Survey, 2015). 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 (Haselkorn, Stewart, & Horn-Ross, 2003). 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 (Ahn, Kim, & Welch, 2014; Haselkorn et al., 2015). While Filipinos have a higher healthcare access rate and lower poverty rate than other Asian subgroups (California Health Interview Survey, 2015), 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 (California Health Interview Survey, 2015; Mohandas, 2011), the causes of this apparent lack of vulnerability, especially for colorectal cancer, are worth further study.

Overall, these results complement previously published research (Gomez et al., 2013; Miller et al., 2008; McCracken et al., 2007). In the most recent publication on this subject, Gomez et al. (2013) reported incidence rates by Asian subgroup for five of the most common cancer sites for the period 2004-2008. 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 (Kohler et al., 2015).

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. (2009). 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 (North American Association of Central Cancer Registries, 2016b). 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 (Liu et al., 2012; Lee, Chen, Jung, Baezconde-Garbanati, & Juon, 2014). 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.

Disclaimers

The Florida cancer incidence data used in this report were collected by the Florida Cancer Data system under contract with the Department of Health (DOH). The views expressed herein are solely those of the author(s), and do not necessarily reflect those of the contractor of DOH.

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.

Chapter 4

Stomach Cancer Survival among US Asian American Populations

Introduction

Stomach cancer is the third leading cause of cancer death and the fifth most common cancer worldwide, with some of the highest incidence and mortality rates found in the Eastern Asian countries of China, Japan, and Korea (International Agency for Research on Cancer, 2016). In the United States (US), the fastest growing minority population is Asian American, due to an immigration surge from these and other Asian countries, including India, Vietnam, and Philippines (US Census, 2012a). Not surprisingly, this ongoing demographic shift is impacting the stomach cancer profile in the US (International Agency for Research on Cancer, 2016). While overall stomach cancer incidence and mortality rates have decreased steadily in the past two decades, survival remains relatively low compared to other cancers, at least in part due to a high proportion of diagnoses at an advanced stage (Howlader et al., 2015).

Compared to non-Hispanic whites, Asian Americans, as a whole, have higher stomach cancer incidence, but also have better survival outcomes (Jin, Pinheiro, Xu, & Amei, 2015; Gomez et al., 2013; Wang, Sun, & Bertagnolli, 2015; Bonenkamp et al., 1993; Strong et al., 2010; Davis & Sano, 2001; Theuer, Kurosaki, Ziogas, Butler, & Anton-Culver, 2000; Nelson et al., 2013; Howard, Hiles, Leung, Stern, & Bilchik, 2015; Theuer, 2000; Gill, Shah, Le, Cook, & Yoshida, 2003; Kim et al., 2009; Merchant, Li, & Kim, 2014; Schwarz & Zagala-Nevarez, 2002; Kim et al., 2009). Previous research, while not conclusive, has linked the survival advantage of Asian Americans to tumors at a more distal anatomic site, diagnosis at earlier tumor stages, diagnosis at younger ages, and more aggressive treatment approaches (Wang, Sun, & Bertagnolli, 2015; Bonenkamp et al., 1993;

Strong et al., 2010; Davis & Sano, 2001; Theuer, Kurosaki, Ziogas, Butler, & Anton-Culver, 2000; Nelson et al., 2013; Howard, Hiles, Leung, Stern, & Bilchik, 2015; Theuer, 2000; Gill, Shah, Le, Cook, & Yoshida, 2003; Kim et al., 2009; Merchant, Li, & Kim, 2014; Schwarz & Zagala-Nevarez, 2002; Kim et al., 2009). Identifying the causes of survival disparities between racial and ethnic groups has the potential to shed light on prognostic factors as well as protective attributes, and inform public health professionals tasked with reducing those disparities while improving cancer outcomes for all populations.

Most cancer research to date has treated the Asian American population in the aggregate (Gomez et al., 2014). However, this population is heterogeneous, not only genetically, but also with respect to lifestyle, culture, immigration and settlement experiences (Pew Research Center, 2013). Aggregation of all Asians in epidemiological research ignores potential Asian subgroup variation in critical factors that impact cancer survival, including sociodemographic factors, tumor characteristics, healthcare access and quality, and cancer coping mechanisms (Gomez et al., 2014). Cancer survival patterns may differ between Asian subgroups in the US as well as between these subgroups and non-Hispanic whites. In order to elucidate the true factors responsible for stomach cancer survival disparities, with the ultimate aim of improving outcomes for all Americans, it is important to carefully characterize these subgroup differences for comparison with each other as well as the majority non-Hispanic white population.

In the current study, we use the Surveillance, Epidemiology, and End Results (SEER) Program data from 2000 through 2012 to calculate 5-year stomach cancer survival estimates for non-Hispanic whites and the six largest Asian subgroups in the US: Chinese, Filipino, Japanese, Korean, South Asian, and Vietnamese. Survival differences between these subgroups as well as in

comparison to non-Hispanic whites were examined after adjustment for the known important prognostic factors in stomach cancer survival.

Material and Methods

Study Purpose

The purpose of this study is to investigate stomach cancer survival disparities among Asian Americans in the US.

Research Question

Do stomach cancer survival disparities exist among specific Asian subgroups?

Hypotheses

Hypothesis 1

H_0: Age-adjusted overall stomach cancer 5-year survival do not vary between non-Hispanic whites and Asians from 2000 to 2012

H_A: Age-adjusted overall stomach cancer 5-year survival vary between non-Hispanic whites and Asians from 2000 to 2012

Hypothesis 2

H_0: Age-adjusted overall stomach cancer 5-year survival do not vary between Asian subgroups from 2000 to 2012

H_A: Age-adjusted overall stomach cancer 5-year survival vary between Asian subgroups from 2000 to 2012

Hypothesis 3

H_0: Age-adjusted stage-specific stomach cancer 5-year survival do not vary between non-Hispanic whites and Asians from 2000 to 2012

H_A: Age-adjusted stage-specific stomach cancer 5-year survival vary between non-Hispanic whites and Asians from 2000 to 2012

Hypothesis 4

H_0: Age-adjusted stage-specific stomach cancer 5-year survival do not vary between Asian subgroups from 2000 to 2012

H_A: Age-adjusted stage-specific stomach cancer 5-year survival vary between Asian subgroups from 2000 to 2012

Hypothesis 5

H_0: Age-adjusted subsite-specific stomach cancer 5-year survival do not vary between non-Hispanic whites and Asians from 2000 to 2012

H_A: Age-adjusted subsite-specific stomach cancer 5-year survival vary between non-Hispanic whites and Asians from 2000 to 2012

Hypothesis 6

H_0: Age-adjusted subsite-specific stomach cancer 5-year survival do not vary between Asian subgroups from 2000 to 2012

H_A: Age-adjusted subsite-specific stomach cancer 5-year survival vary between Asian subgroups from 2000 to 2012

Hypothesis 7

H_0: Race/ethnicity predicts stomach cancer survival after adjusting for important prognostic factors.

H_A: Race/ethnicity does not predict stomach cancer survival after adjusting for important prognostic factors.

H_{A1}: Asian race predicts better stomach cancer survival than non-Hispanic whites after adjusting for important prognostic factors.

H_{A2}: Specific Asian ethnicity predicts better stomach cancer survival than non-Hispanic whites after adjusting for important prognostic factors.

Study Population and Covariates

Population-based cancer data for non-Hispanic whites and Asians (regardless of Hispanic ethnicity) aged 15 years or older were obtained from the SEER 18 registries, which cover 25% of the white and 50% of the Asian American population in the US (Surveillance, Epidemiology, and End Results Program, 2010). Cases selected for analysis had an invasive tumor of the stomach diagnosed during the 13-year period from January 1, 2000 through December 31, 2012. Excluded cases were younger than 15 years old, diagnosed only at death or during autopsy, and those with a second or subsequent malignancy.

Net survival was calculated using a cause-specific survival framework, based on the SEER classification of cause-specific death (Howlader et al., 2010). Using the reported alive method, survival time was calculated in months from the date of diagnosis to whichever occurred first: the date of death from stomach cancer, the date of last alive follow-up, or the final date of the study

period, December 31, 2012. Those with zero survival time were excluded; cases were censored at date lost to follow up or date of death from other causes. We censored all cases at a cutoff of 60 months for survival analysis.

Eleven specific Asian subgroups are coded in the North American Association of Central Cancer Registries (NAACCR) standards: Asian Indian, Chinese, Filipino, Hmong, Japanese, Kampuchean, Korean, Laotian, Pakistani, Thai, and Vietnamese (NAACCR, 2015). The NAACCR Asian/Pacific Islander Identification Algorithm (NAPIIA) enhances the identification of Asian subgroup status by using name and birthplace information (Hsieh, Pareti, & Chen, 2011). We aggregated Asian Indian and Pakistani into one single category, South Asian, because the NAACCR protocol did not code them separately until 2010 (NAACCR, 2015), and examined the 6 largest US Asian subgroups, hereafter referred to as Asian ethnicities: Chinese, Filipino, Japanese, Korean, South Asian, and Vietnamese. Smaller Hmong, Kampuchean, Laotian, and Thai populations as well as Asian cases with unknown ethnicity were combined into a single Other Asian category; however, they are not included in the survival analyses.

Other sociodemographic variables assessed for impact on survival were sex, age, marital status, insurance status, and socioeconomic status (SES). International age standard survival classification categories were used to form 5 age groups: 15-44, 45-54, 55-64, 65-74, and 75+ (Corazziari, Quinn, & Capocaccia, 2004]. Insurance status was grouped into 4 mutually exclusive groups: insured, which included Medicare and private insurance; Medicaid, including dual-eligible Medicaid/Medicare cases; uninsured; and unknown. Data on socioeconomic status (SES), reflecting aspects of social stratification that play a critical role in cancer survival, are not routinely collected at the individual level by cancer registries. Using census tract information on cases, we

adopted a quintile SES index that has been shown to detect socioeconomic gradients in cancer survival (Yu, Tatalovich, Gibson, & Cronin, 2014)

Routinely collected clinical data for each stomach cancer case, including primary anatomic site, histology, grade, and staging, were coded and reported according to the International Classification of Diseases for Oncology, Third Edition (ICD-O-3). Anatomic site was divided into four sublocations: cardia (C16.0); middle, comprising fundus, body, or curvatures (C16.1, C16.2, C16.5, and C16.6); distal, including antrum or pylorus (C16.2 and C16.3); and overlapping or not otherwise specified (NOS) (C16.8 and C16.9). Histological types were categorized according to the Lauren's classification and previous studies (Lauren, 1965; Pinheiro, van der Heijden, & Coebergh, 1999) into either diffuse type (codes 8020-8022, 8142, 8145, and 8490), intestinal type (8140, 8144, 8210-8211, 8260, and 8480- 8481), NOS (8000-8010), or other. Additional clinical covariates included SEER stage at diagnosis (localized, regional, distant, and unknown), tumor grade (I-IV and unknown), and treatment modality (surgery and radiation).

Statistical Analyses

Sociodemographic and clinical characteristics by race and Asian ethnicity were summarized with descriptive statistics. Five-year age-standardized overall survival, as well as survival stratified by anatomic site and stage at diagnosis, was calculated using the life table method (Corazziari, Quinn, & Capocaccia, 2004).

Univariate analyses to determine significant prognostic factors were performed using the log-rank test, and covariates were tested for interaction effects. Multivariate survival analyses using Cox proportional hazards regression models produced hazard ratios (HRs) and corresponding 95% confidence intervals (CIs) for risk of stomach cancer-specific mortality. The proportional hazards

assumption, assessed by visual inspection of the log (-log) plot of the survival distribution for each independent variable, had no significant violations. Variables were included via forward stepwise selection to assess the relative impact of significant prognostic factors.

Curative and palliative surgical treatments cannot be differentiated by cancer registry data. However, the goals of surgical management of stomach cancer largely depend on the stage at diagnosis. In order to assess the factors affecting receipt of curative-intent surgery, we assumed that surgeries in patients with localized stomach cancer are curative-intent. Multivariate stepwise logistic regression was used to estimate odds ratios (ORs) and 95% confidence intervals (CIs) for receipt of curative-intent surgery.

All statistical tests were 2-sided with a significance level of 0.05. All analyses were performed with SAS 9.3.

Results

A total of 33,313 non-Hispanic white and 8,473 Asian stomach cancer cases were studied. The distribution of Asians by ethnic group was as follows: 24% Korean, 24% Chinese, 21% Japanese, 12% Filipino, 10% Vietnamese, 5% South Asian, and 5% other Asian. Sociodemographic and clinical characteristics varied significantly between Asians and non-Hispanic whites, as well as between Asian ethnicities.

Table 17. Sociodemographic characteristics by race and Asian ethnicity in patients with stomach cancer, 2000-2012[*]

	Chinese		Filipino		Japanese		Korean		South Asian		Vietnamese		Other Asian		Total Asian		NH white	
	(N=2022)		(N=990)		(N=1739)		(N=2034)		(N=416)		(N=866)		(N=406)		(N=8473)		(N=33313)	
Characteristic	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Sex																		
Male	1153	57.0	506	51.1	932	53.6	1178	57.9	254	61.1	515	59.5	223	54.9	4761	56.2	21257	63.8
Female	869	43.0	484	48.9	807	46.4	856	42.1	162	38.9	351	40.5	183	45.1	3712	43.8	12056	36.2
Age at diagnosis																		
15-44	142	7.0	74	7.5	37	2.1	154	7.6	75	18.0	87	10.0	60	14.8	629	7.4	1631	4.9
45-54	223	11.0	121	12.2	116	6.7	300	14.7	82	19.7	138	15.9	59	14.5	1039	12.3	3996	12.0
55-64	341	16.9	214	21.6	215	12.4	439	21.6	95	22.8	176	20.3	89	21.9	1569	18.5	7015	21.1
65-74	502	24.8	245	24.7	426	24.5	625	30.7	85	20.4	211	24.4	97	23.9	2191	25.9	8434	25.3
75+	814	40.3	336	33.9	945	54.3	516	25.4	79	19.0	254	29.3	101	24.9	3045	35.9	12237	36.7
Marital status																		
Never married	161	8.0	71	7.2	169	9.7	173	8.5	31	7.5	91	10.5	50	12.3	746	8.8	3437	10.3
Married	1399	69.2	638	64.4	1061	61.0	1412	69.4	300	72.1	588	67.9	251	61.8	5649	66.7	19491	58.5
Previously married	394	19.5	249	25.2	456	26.2	368	18.1	62	14.9	149	17.2	90	22.2	1768	20.9	8811	26.4
Unknown	68	3.4	32	3.2	53	3.0	81	4.0	23	5.5	38	4.4	15	3.7	310	3.7	1574	4.7
Insurance status																		
Uninsured	50	2.5	28	2.8	12	0.7	106	5.2	29	7.0	20	2.3	14	3.4	259	3.1	959	2.9
Any Medicaid	408	20.2	122	12.3	29	1.7	314	15.4	59	14.2	226	26.1	86	21.2	1244	14.7	1759	5.3
Insured	1004	49.7	473	47.8	805	46.3	730	35.9	233	56.0	320	37.0	168	41.4	3733	44.1	19097	57.3
Unknown	560	27.7	367	37.1	893	51.4	884	43.5	95	22.8	300	34.6	138	34.0	3237	38.2	11498	34.5
SES, quintile																		
1 (lowest)	250	12.4	103	10.4	115	6.6	323	15.9	32	7.7	145	16.7	110	27.1	1078	12.7	4465	13.4
2	227	11.2	162	16.4	249	14.3	292	14.4	37	8.9	189	21.8	68	16.7	1224	14.4	6290	18.9
3	318	15.7	229	23.1	376	21.6	291	14.3	54	13.0	215	24.8	66	16.3	1549	18.3	7055	21.2
4	458	22.7	259	26.2	450	25.9	440	21.6	107	25.7	171	19.7	70	17.2	1955	23.1	7545	22.6
5	739	36.5	229	23.1	536	30.8	610	30.0	180	43.3	141	16.3	88	21.7	2523	29.8	7468	22.4
Unknown	30	1.5	8	0.8	13	0.7	78	3.8	6	1.4	5	0.6	4	1.0	144	1.7	490	1.5

[*] Totals may not equal 100% due to rounding.

In both races and every Asian ethnic group, cases were more likely to be male than female: the widest difference was seen in non-Hispanic whites, 64% male and 36% female; the narrowest in

Filipinos, at 51% male and 49% female. Age at diagnosis distributions differed significantly, with a much higher proportion of South Asians (38%) diagnosed younger than 55 years of age than non-Hispanic whites (17%) or any other Asian ethnicity. Conversely, Japanese cases had almost 80% of cases diagnosed at ages older than 65, higher than all other comparison groups, including non-Hispanic whites at 62% and Koreans at 56% (Table 17)

Table 18. Clinical characteristics by race in patients with stomach cancer, 2000-2012*

	Chinese		Filipino		Japanese		Korean		South Asian		Vietnamese		Other Asian		Total Asian		NH white	
	(N=2022)		(N=990)		(N=1739)		(N=2034)		(N=416)		(N=866)		(N=406)		(N=8473)		(N=33313)	
Characteristic	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Year of diagnosis																		
2000-2003	579	28.6	273	27.6	630	36.2	574	28.2	97	23.3	233	26.3	97	23.9	2478	29.2	10607	31.8
2004-2007	610	30.2	317	32.0	538	30.9	679	33.4	126	30.3	298	33.6	116	28.6	2677	31.6	10198	30.6
2008-2012	833	41.2	400	40.4	571	32.8	781	38.4	193	46.4	355	40.1	193	47.5	3318	39.2	12508	37.5
Stage at diagnosis																		
Localized	552	27.3	268	27.1	523	30.1	701	34.5	127	30.5	197	22.7	114	28.1	2482	29.3	9429	28.3
Regional	684	33.8	289	29.2	544	31.3	655	32.2	110	26.4	296	34.2	110	27.1	2688	31.7	8776	26.3
Distant	585	28.9	349	35.3	534	30.7	518	25.5	134	32.2	305	35.2	133	32.8	2558	30.2	11661	35.0
Unknown	201	9.9	84	8.5	138	7.9	160	7.9	45	10.8	68	7.9	49	12.1	745	8.8	3447	10.3
Anatomic site																		
Cardia	222	11.0	192	19.4	230	13.2	99	4.9	93	22.4	75	8.7	40	9.9	951	11.2	13245	39.8
Middle	601	29.7	299	30.2	567	32.6	684	33.6	121	29.1	255	29.4	115	28.3	2642	31.2	7468	22.4
Distal	736	36.4	242	24.4	531	30.5	780	38.3	90	21.6	330	38.1	140	34.5	2849	33.6	5165	15.5
Overlapping/NOS	463	22.9	257	26.0	411	23.6	471	23.2	112	26.9	206	23.8	111	27.3	2031	24.0	7435	22.3
Histology																		
Intestinal	1226	60.6	523	52.8	1098	63.1	1263	62.1	198	47.6	517	59.7	228	56.2	5053	59.6	20814	62.5
Diffuse	521	25.8	274	27.7	414	23.8	561	27.6	105	25.2	247	28.5	107	26.4	2229	26.3	6255	18.8
NOS	84	4.2	32	3.2	52	3.0	78	3.8	9	2.2	29	3.3	20	4.9	304	3.6	1404	4.2
Other	191	9.4	161	16.3	175	10.1	132	6.5	104	25.0	73	8.4	51	12.6	887	10.5	4840	14.5
Grade																		
I	75	3.7	32	3.2	94	5.4	76	3.7	28	6.7	28	3.2	13	3.2	346	4.1	1701	5.1
II	376	18.6	194	19.6	406	23.3	427	21.0	74	17.8	173	20.0	68	16.7	1718	20.3	7169	21.5
III	1157	57.2	540	54.5	991	57.0	1222	60.1	192	46.2	508	58.7	234	57.6	4844	57.2	15849	47.6
IV	44	2.2	21	2.1	30	1.7	23	1.1	6	1.4	16	1.8	10	2.5	150	1.8	763	2.3
Unknown	370	18.3	203	20.5	218	12.5	286	14.1	116	27.9	141	16.3	81	20.0	1415	16.7	7831	23.5
Surgery																		
Yes	1263	62.5	536	54.1	1061	61.0	1399	68.8	228	54.8	522	60.3	215	53.0	5224	61.7	16164	48.5
No	756	37.4	449	45.4	661	38.0	630	31.0	184	44.2	343	39.6	190	46.8	3213	37.9	16882	50.7
Unknown	3	0.1	5	0.5	17	1.0	5	0.2	4	1.0	1	0.1	1	0.2	36	0.4	267	0.8
Radiation																		
Yes	458	22.7	235	23.7	373	21.4	410	20.2	101	24.3	193	22.3	66	16.3	1836	21.7	8319	25.0
No	1543	76.3	742	74.9	1329	76.4	1600	78.7	304	73.1	657	75.9	333	82.0	6508	76.8	24296	72.9
Unknown	21	1.0	13	1.3	37	2.1	24	1.2	11	2.6	16	1.8	7	1.7	129	1.5	698	2.1

* Totals may not equal 100% because of rounding

The greatest variations were observed in gastric tumor characteristics. Non-Hispanic whites had a 3.5 times higher proportion of cardia tumors than Asians in the aggregate, but nearly 8 times higher than the largest Asian ethnic group in our study, Koreans. Most Asian ethnicities had a similar proportion as non-Hispanic whites of tumors diagnosed at the localized stage, approximately 28%, but Koreans had a larger share (35%) and Vietnamese had much lower (23%), resulting in a 1.5-fold difference between these two groups (Table 18).

Every Asian ethnic group had a significantly more favorable 5-year survival proportion than non-Hispanic whites, who had the lowest, at 29.8% (Table 19). Among Asians, Koreans had the highest survival at 45.4%. Vietnamese and Filipinos were relatively low, at 35.7% and 36.4% respectively. After stratification by anatomic site, survival patterns in the Asian ethnic groups altered considerably, although non-Hispanic whites retained significantly lower survival rates at every anatomic site. Chinese, South Asians, and Koreans showed the best survival for cardia, middle, and distal stomach cancer, respectively. Similarly, after stratification by stage at diagnosis, the survival advantage in Koreans only remained for localized stomach cancer, while Chinese and Filipinos had highest survival in regional and distant stomach cancers, respectively. As with anatomic site, non-Hispanic whites had worse survival than Asians for every stage of diagnosis.

Table 19. Age-standardized 5-year survival by race and Asian ethnicity in patients with gastric cancer, 2000-2012[*]

	Chinese		Filipino		Japanese		Korean		South Asian		Vietnamese		Other Asian		Total Asian		NH white	
	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)	%	(95% CI)
Overall																		
	42.2	(39.7-44.7)	36.4	(32.8-40.0)	38.6	(36.0-41.2)	45.4	(43.0-47.9)	43.4	(37.6-49.1)	35.7	(32.0-39.4)	36.8	(31.2-42.4)	40.7	(39.5-41.9)	29.8	(29.2-30.3)
Anatomic site																		
Cardia	37.1	(29.7-44.6)	28.6	(20.5-36.7)	28.4	(21.7-35.1)	35.0	(23.7-46.3)	25.1	(13.3-37.0)	17.8	(6.5-29.2)	28.3	(10.3-46.3)	30.9	(27.3-34.4)	23.1	(22.3-24.0)
Middle	51.5	(46.9-56.1)	43.8	(37.1-50.4)	49.8	(45.2-54.5)	51.9	(47.6-56.1)	54.7	(44.1-65.4)	47.3	(40.3-54.4)	41.6	(30.5-52.7)	49.4	(47.2-51.6)	41.4	(40.1-42.6)
Distal	44.2	(40.1-48.4)	37.1	(29.9-44.3)	43.0	(38.3-47.7)	53.9	(50.0-57.9)	46.8	(34.5-59.2)	39.7	(33.8-45.7)	33.0	(23.4-42.7)	44.9	(42.8-47.0)	35.1	(33.7-36.6)
Overlapping/NOS	28.8	(24.1-33.6)	32.6	(25.9-39.3)	27.2	(22.5-31.9)	25.7	(21.1-30.3)	40.8	(30.3-51.4)	20.6	(14.1-27.1)	37.2	(27.6-46.7)	28.4	(26.1-30.6)	26.5	(25.3-27.6)
Stage																		
Localized	77.7	(73.3-82.1)	71.1	(64.3-77.9)	77.6	(73.2-81.9)	83.7	(80.5-86.9)	76.8	(69.2-84.4)	72.9	(65.3-80.5)	68.6	(58.5-78.8)	78.3	(76.3-80.3)	66.1	(65.0-67.2)
Regional	44.7	(40.4-48.9)	39.0	(31.9-46.0)	41.7	(37.1-46.3)	41.1	(36.9-45.4)	36.7	(25.0-48.4)	41.2	(35.0-47.5)	39.5	(28.5-50.5)	40.7	(38.6-42.9)	27.0	(25.9-28.1)
Distant	9.0	(5.9-12.1)	10.7	(6.9-14.6)	7.7	(5.2-10.2)	6.5	(3.9-9.2)	7.2	(1.5-12.8)	9.2	(5.2-13.2)	5.5	(0.0-11.0)	7.8	(6.5-9.1)	5.4	(4.9-5.9)

In univariate survival analyses, the following variables were significant predictors for stomach cancer survival: sex, age at diagnosis, marital status, insurance status, SES, year of diagnosis, cancer registry, stage at diagnosis, anatomic site, histology, grade, treatment by surgery and treatment by radiation. Nonetheless, treatment modalities were not included in the multivariate survival analyses primarily because they were largely dependent upon stage at diagnosis and anatomic site, but also because cancer registry data does not differentiate between curative and palliative treatments. Due to strong interaction with SES and a high proportion of unknowns, insurance status was also not included. Similarly, grade was excluded due to a significant interaction with stage at diagnosis.

Given the variations in 5-year survival by tumor characteristics, three separate models were generated to examine their impacts on racial and ethnic group disparities (Table 20). After adjusting for histology and other major prognostic variables (Model 1), Koreans showed significantly better survival than non-Hispanic whites and every other Asian ethnic group. Adjusting for anatomic site yielded the same, although attenuated results: all Asian groups as well as non-Hispanic whites were at higher risk of death from stomach cancer when compared to Koreans (Model 2). However, after taking into account stage at diagnosis, any survival disparity between Asian ethnicities disappeared (Model 3). However, even after controlling for all prognostic factors available in our study, non-Hispanic whites had a significant survival disadvantage compared to all Asians: 33% more likely to die after stomach cancer diagnosis.

In addition to race, other prognostic factors that significantly predicted stomach cancer survival were stage at diagnosis, which showed a 6.5-fold increment in risk of death from distant stage to localized stage; histology, with diffuse type tumors predicting1.23 times increased risk of death over intestinal type; and anatomic site, where cardia gastric tumors showed the worst survival, 16%

increased risk over distal tumors. Additionally, the risk of death was 21% higher in the lowest SES quartile than the highest, and mortality risk steadily decreased with increasing SES.

Table 20. Risk of death from gastric cancer by prognostic factor among Asian American and non-Hispanic white patients, 2000-2012

	Model 1*			Model 2†			Model 3‡		
	HR	(95% CI)	p-value	HR	(95% CI)	p-value	HR	(95% CI)	p-value
Race/ethnicity									
Korean	-	-	-	-	-	-	-	-	-
Chinese	1.15	(1.05-1.26)	<0.01	1.14	(1.04-1.24)	0.01	1.01	(0.92-1.11)	0.83
Japanese	1.26	(1.15-1.39)	<0.01	1.23	(1.12-1.36)	<0.01	1.05	(0.95-1.16)	0.32
Filipino	1.38	(1.24-1.54)	<0.01	1.33	(1.19-1.48)	<0.01	1.10	(0.99-1.23)	0.08
South Asian	1.29	(1.10-1.52)	<0.01	1.24	(1.05-1.45)	0.01	1.06	(0.90-1.24)	0.48
Vietnamese	1.27	(1.14-1.42)	<0.01	1.27	(1.14-1.42)	<0.01	1.07	(0.95-1.19)	0.25
Non-Hispanic white	1.70	(1.59-1.82)	<0.01	1.58	(1.48-1.70)	<0.01	1.33	(1.24-1.43)	<0.01
SES, quintile									
5 (highest)	-	-	-	-	-	-	-	-	-
4	1.06	(1.02-1.10)	<0.01	1.06	(1.02-1.10)	<0.01	1.05	(1.02-1.09)	0.01
3	1.10	(1.06-1.14)	<0.01	1.10	(1.06-1.14)	<0.01	1.12	(1.08-1.17)	<0.01
2	1.13	(1.09-1.18)	<0.01	1.13	(1.09-1.18)	<0.01	1.16	(1.11-1.20)	<0.01
1	1.15	(1.10-1.21)	<0.01	1.16	(1.11-1.21)	<0.01	1.21	(1.15-1.26)	<0.01
Unknown	1.02	(0.91-1.14)	0.74	1.02	(0.91-1.14)	0.74	1.05	(0.94-1.17)	0.40
Histology									
Intestinal	-	-	-	-	-	-	-	-	-
Diffuse	1.28	(1.24-1.32)	<0.01	1.28	(1.24-1.32)	<0.01	1.23	(1.19-1.27)	<0.01
NOS	1.60	(1.51-1.69)	<0.01	1.41	(1.33-1.49)	<0.01	1.22	(1.15-1.30)	<0.01
Other	0.32	(0.30-0.34)	<0.01	0.31	(0.30-0.33)	<0.01	0.41	(0.39-0.43)	<0.01
Anatomic site									
Distal	-	-	-	-	-	-	-	-	-
Middle				1.05	(1.01-1.10)	0.01	1.01	(0.97-1.06)	0.54
Cardia				1.28	(1.23-1.33)	<0.01	1.16	(1.11-1.20)	<0.01
Overlapping/NOS				1.62	(1.56-1.69)	<0.01	1.30	(1.25-1.35)	<0.01
Stage at diagnosis									
Localized	-	-	-	-	-	-	-	-	-
Regional							2.36	(2.26-2.46)	<0.01
Distant							6.49	(6.23-6.76)	<0.01
Unknown							3.37	(3.19-3.55)	<0.01

* Model 1 was adjusted for race, sex, SES, age at diagnosis, marital status, year of diagnosis, cancer registry, and histology

† Model 2 was adjusted for model 1 variables plus anatomic site

‡ Model 3 was adjusted for model 2 variables plus stage at diagnosis

Among patients with localized stomach cancer, non-Hispanic whites had the lowest proportion of receiving surgery at 70% while Koreans had the highest at 90% (Table 21). As a palliative approach alone or a postoperative and intraoperative additional therapy, the overall radiation usage was low, but still higher in non-Hispanic whites than Asian subgroups.

Table 21. Surgery and radiation by race in patients with localized stomach cancer , 2000-2012[*]

	Chinese (n=552)	Filipino (n=268)	Japanese (n=523)	Korean (n=701)	South Asian (n=127)	Vietnamese (n=197)	Other Asian (n=114)	Total Asian (n=2482)	NH white (n=9429)
Characteristic	%	%	%	%	%	%	%	%	%
Surgery									
No	20.8	25.4	17.8	10.4	26.8	19.3	28.1	18.3	29.9
Yes	79.2	74.3	81.5	89.6	73.2	80.7	71.1	81.5	69.4
Unknown		0.4	0.8				0.9	0.2	0.7
Radiation									
No	89.1	86.9	88.5	92.2	85.0	90.4	90.4	89.6	80.7
Yes	10.9	12.3	10.1	7.0	14.2	8.6	8.8	9.7	17.6
Unknown		0.7	1.3	0.9	0.8	1.0	0.9	0.8	1.7

[*] Totals may not equal 100% because of rounding

Table 22. Odds ratios and 95% CIs for receipt of curative-intent surgery among patients with localized stomach cancer, 2000-2012[*]

	OR	(95% CI)	p-value
Race			
Non-Hispanic white	-	-	-
Chinese	1.23	(0.97-1.56)	0.09
Japanese	1.62	(1.22-2.15)	<0.01
Filipino	0.95	(0.70-1.29)	0.73
Korean	2.00	(1.52-2.62)	<0.01
South Asian	0.57	(0.38-0.88)	0.01
Vietnamese	1.28	(0.87-1.87)	0.21
SES, quintile			
1 (lowest)	-	-	-
2	1.20	(1.03-1.40)	0.02
3	1.29	(1.11-1.49)	<0.01
4	1.32	(1.13-1.53)	<0.01
5	1.44	(1.23-1.68)	<0.01
Unknown	1.36	(0.93-1.99)	0.11
Histology			
Intestinal	-	-	-
Diffuse	0.72	(0.63-0.82)	<0.01
NOS	0.38	(0.28-0.51)	<0.01
Other	1.58	(1.39-1.78)	<0.01
Anatomic site			
Cardia	-	-	-
Middle	2.62	(2.32-2.96)	<0.01
Distal	3.04	(2.66-3.48)	<0.01
Overlapping/NOS	1.26	(1.10-1.43)	<0.01

[*] Model was adjusted for race, SES, age at diagnosis, marital status, year of diagnosis, cancer registry, histology, and anatomic site

The odds of having curative-intent surgery in patients with localized stomach cancer varied significantly by prognostic factor. Patients who were younger at diagnosis, having higher SES,

currently married, and having tumors with less aggressive histological type and more distal anatomic site were more likely to receive surgical treatment (Table 22). After adjusting for potential confounders, Koreans and Japanese were 2 times and 1.6 times more likely to receive surgery than non-Hispanic whites, respectively.

Discussion

The striking difference in stomach cancer survival between Asian and Western countries has been the subject of much research (Gill et al., 2003; Kim et al., 2009; Merchant et al., 2014; Bickenbach & Strong, 2012; Yamamoto, Rashid, & Wong, 2015). With the burgeoning Asian American population in the US, SEER registries provides a unique platform to investigate this gap by examining differences not only between non-Hispanic whites and Asians overall, but between specific Asian ethnic groups within the same country. The results of our study showed that all of the six largest Asian ethnicities in the US had significantly higher 5-year survival than non-Hispanic whites. Koreans had substantially higher 5-year survival than other Asian groups, especially Vietnamese. However, the disparate stomach cancer survival between Asian subgroups could not be attributed to ethnicity alone; rather it is more likely stems from a different case mix of important prognostic factors. Conversely, a persistent survival gap was observed between Asians and non-Hispanic whites, even after adjustment for age, histology, sublocation of the tumor, and other covariates. While sociodemographic factors such as younger age composition, better insurance, and higher SES improved prognosis for stomach cancer survival, tumor characteristics – notably, stage at diagnosis, histology, and anatomic site – were the most critical predictors, attenuating and/or eliminating observed ethnic and racial differences.

Stage at diagnosis was the single strongest contributor to differential survival among stomach cancer patients. Early tumor detection is critical to improve early stage diagnosis, but unfortunately most early stage stomach cancer cases and even a large number of advanced cases are clinically asymptomatic (Kim, Heo, Kim, Kim, & Kim, 2013). Nonetheless, the known poor prognosis for distant-stage stomach cancer diagnoses has been the driver for increased efforts to detect tumors before symptoms are manifest (Kim et al., 2013; Dan, So, & Yeoh, 2006; Yeh, Hur, Ward, Schrag

& Goldie, 2015). For high-risk populations, research has shown that stomach cancer screening at a rational interval is cost-effective (Dan et al., 2006; Yeh et al., 2015). However, given the relatively low and still declining overall incidence and mortality rates, population-based screening for stomach cancer is not currently recommended in the US. Thus, the utilization of stomach cancer screening services is largely opportunistic, depending largely on individuals' screening awareness and willingness.

In contrast to the US, in response to high stomach cancer incidence, Japan and South Korea have implemented free population-based stomach cancer screening since 1983 and 1999, respectively, to increase early diagnosis and improve survival (Yoo, 2008; Mizoue et al., 2003). In Japan, the current guideline recommends either an annual upper gastrointestinal barium X-ray examination or an upper gastrointestinal endoscopy every two to three years for individuals older than 50 years. The guidelines in Korea recommend upper gastrointestinal endoscopy every two years for individuals aged 40 to 75 years (Hamashima, Kim, & Choi, 2015). In our study, stage at diagnosis explains much of the Korean advantage in relation to other Asian ethnicities and to non-Hispanic whites, as demonstrated by the model changes seen in Table 3. Overall, Koreans, who are 79% foreign-born (Pew Research Center, 2013) show a favorable stage distribution compared to all other groups. It is possible that due to the high stomach cancer incidence and accompanying national public health strategy in Korea, stomach cancer screening awareness, likely consolidated in native Koreans, is carried by Korean immigrants to the US. This may contribute to their advantageous proportions of localized and distant stomach cancers, highest and lowest respectively, compared to non-Hispanic whites and other Asian ethnic groups in the US. On the other hand, since 68% of Japanese are US-born (Pew Research Center, 2013), their screening awareness for stomach cancer is likely more similar to non-Hispanic whites, potentially explaining

the less favorable stage distribution observed in this study, with proportions of localized tumors that are no different from the Asian average or even that of non-Hispanic whites.

While stage at diagnosis greatly influences survival time, stomach cancer remains an aggressive cancer for all stages, and is difficult to treat. Our study shows that a favorable stage distribution is not the only source of the stomach cancer survival advantage in Asian Americans because even in stratified analyses, non-Hispanic whites had lower 5-year survival in all stages. Moreover, the Korean survival advantage over other Asian ethnicities only held for localized stomach cancers; for distant stage diagnoses, Koreans were worse than other Asian groups and not significantly better than non-Hispanic whites. Therefore, other tumor factors must also play a role in explaining survival differences.

Stomach cancer demonstrates marked heterogeneity at the histological level. According to Lauren's classification, the two major histologic subtypes are intestinal type and diffuse type, and these are associated with different survival expectancy (Lauren, 1965). Concurrent with previous research, our study shows that cases with tumors of diffuse type have a significantly higher risk of death than those with the more common intestinal type (Kim et al., 2009; Pinheiro et al., 1999). Diffuse type, more common in females and young individuals, is characterized by the presence of poorly differentiated tumor cells (Hu et al., 2012; Yang et al., 2011). Given a higher male to female sex ratio and older age composition observed in non-Hispanic whites, they had a lower proportion of diffuse type histology than Asians, as expected. In our study, the distribution of histological subtypes was similar across all Asian ethnicities; Filipinos and South Asians had a lower proportion of the favorable intestinal type histology and Vietnamese had somewhat higher diffuse types. However, histological characteristics alone are not sufficient to explain the ethnic and racial survival differences observed.

Tumor anatomic site, whose distribution varied considerably by race and Asian ethnicity, is a major determinant of stomach cancer survival, as shown in this and previous studies (Kim et al., 2009; Pinheiro et al., 1999). Anatomic site determines treatment options, which impact survival. For stomach cancer, surgery is the only curative treatment option, and the extent of gastric resection and margins largely depends on the location of the tumor. Tumors located in the distal part of the stomach are commonly treated by subtotal gastrectomy and reconstruction of digestive continuity. However, tumors located at the middle or proximal (cardia) of the stomach may require total gastrectomy or esophagogastrectomy, if extended into a lower esophageal, which result in a relatively worse prognosis (Dikken et al., 2012; Orditura et al., 2014; An et al., 2008; Maruyama, Sasako, Kinoshita, Sano, & Katai, 1996). Previous studies have shown that patients from Western countries have a significantly higher proportion of cardia tumors, while patients in Asia have a higher proportion of non-cardia stomach cancer. This variation could be attributed to risk factor prevalence in these different populations. A major risk factor for non-cardia stomach cancer is Helicobacter pylori infection; obesity and gastroesophageal reflux are associated with cancer in the cardia (Karimi, Islami, Anandasabapathy, Freedman, & Kamangar, 2014; Kamangar, Sheikhattari, & Mohebtash, 2011; Lagergren, Bergström, Lindgren, & Nyrén, 1999)

Non-Hispanic whites in our study verily had a substantially higher proportion of cardia stomach cancer than Asians, yet even after stratification by anatomic demarcation, 5-year survival remained poor. Koreans had a remarkably low proportion of cardia stomach cancer, contributing further to their overall advantage. However, the favorable overall 5-year survival for Koreans over other Asian ethnicities was diminished after stratifying by anatomic site, only remaining significantly better for distal stomach cancer.

Asian race has been shown to be an independent prognostic factor for stomach cancer survival in many studies (Wang, Sun, & Bertagnolli, 2015; Bonenkamp et al., 1993; Strong et al., 2010; Davis & Sano, 2001; Theuer, Kurosaki, Ziogas, Butler, & Anton-Culver, 2000; Nelson et al., 2013; Howard, Hiles, Leung, Stern, & Bilchik, 2015; Theuer, 2000; Gill, Shah, Le, Cook, & Yoshida, 2003; Kim et al., 2009; Merchant, Li, & Kim, 2014; Schwarz & Zagala-Nevarez, 2002). Here, we bolster those findings, demonstrating with multivariate analyses that each of the six major Asian ethnic groups has a survival advantage compared to non-Hispanic whites. Critically, we found that the survival disparities between Asian ethnicities disappeared after controlling for major prognostic factors. To our knowledge, only one previous population-based study assessed the impact of specific Asian groups on stomach cancer survival. Kim et al., using Los Angeles County data, found significant survival disparities: Koreans had the highest and Filipinos had lowest stomach cancer survival (Kim et al., 2009). Using the most current national data available, we found a significant stomach cancer survival disparity between non-Hispanic whites and Asian Americans, but no significant differences within the Asian ethnic groups.

In a separate analysis, we analyzed receipt of surgery for localized stages, which are more likely to have curative-intent, and found that non-Hispanic whites had a lower proportion of surgery than Asians for each tumor anatomic site. However, in a survival model restricted to localized stage stomach cancer, differences in receipt of surgery were not enough to explain the disparities between Asians and non-Hispanic whites. In short, the causes of the survival disadvantage for non-Hispanic whites remain elusive; at the least, they are not discernible based on variables collected by SEER.

Several limitations may have affected our results. First, we used cause-specific death as our outcome which may be impacted by cause of death misclassification on death certificates.

Secondly, since Asians are more likely to have incomplete follow-up compared to non-Hispanic whites and censoring across Asian ethnic groups is neither random nor even (Pinheiro, Morris, Liu, Bungum, & Altekruse, 2014), it is possible that stomach cancer survival among Asians as a whole and/or by subgroup is overestimated. Loss to follow up, which contributes to inflated survival estimates, may occur due to the return of immigrants with serious illnesses to their countries of origin to die, a phenomenon known as the salmon bias (Pinheiro et al., 2014; Razum, 2006). However, studies thus far indicate that salmon bias has limited impact on Asian American survival, likely due to travel being too distant and time-consuming for gravely ill individuals to undertake (Acciai, Noah, & Firebaugh, 2015; Tendulkar et al., 2012). Lastly, comorbidities, such as obesity, heart disease and diabetes, are critical risk factors impacting stomach cancer outcomes, and there is heterogeneity in these comorbidities among Asian ethnic groups. For example, Filipinos have the highest Asian obesity rate (California Health Interview Survey, 2015). However, we were unable to control for comorbidities, as such data are not routinely collected by cancer registries.

This study characterizes the distinctive stomach cancer survival patterns among the six major Asian ethnic groups in the US, and compares these patterns to non-Hispanic whites. While there were observed survival differences between Asian ethnicities, these can largely be attributed to differences in major prognostic factors, such as stage at diagnosis and anatomic site. Therefore stomach cancer survival analyses should always control for these confounding factors, which vary significantly across race and ethnicity.

In addition to the demographic and clinical characteristics studied here, cancer screening awareness and coping mechanisms after cancer diagnosis have important and lasting effects on cancer outcomes. Among immigrants, these are known to be associated with culture and length of stay in the US (Glenn, Chawla, Surani, & Bastani, 2009; Hwang, 2013). Although the lack of

survival disparities among Asian ethnicities does not provide enough clues to explain the survival disadvantage of non-Hispanic whites, revealed ethnic group differences point to the need for increased awareness among all Americans of stomach cancer screening and potential surgical options once diagnosed. This study provided a unique opportunity to better understand the epidemiology of stomach cancer survival at a national level, and can serve to generate future research hypotheses. With the increase in high-risk foreign-born Asian populations in the US reaching stomach cancer ages (US Census Bureau, 2012; Howlader et al., 2015) further public health efforts will be required to identify their protective survival attributes and prevent risk assimilation. Moreover, the vulnerability of non-Hispanic whites for stomach cancer mortality has yet to be explained.

Chapter 5

Conclusions and Recommendations for Further Study

Asian Americans are the most rapidly growing racial/ethnic group in the United States (US), recently surpassing Hispanics in rates of population growth. The immigration flows of foreign-born populations from Asia countries significantly impact the cancer profile of the US. Disparities in cancer incidence and survival among Asian Americans have been largely overlooked because of lack of detailed Asian ethnicity information and stereotypes concerning positive health profiles. However, by acknowledging and leveraging the heterogeneity in Asian Americans, we have a unique opportunity to uncover potential group-specific cancer risk and prognostic factors and advance cancer knowledge. Here, several suggestions shall be considered in further research on cancer disparities among specific Asian subgroups.

1. Increase population coverage and representativeness

Neither the population growth nor the geographic distribution is even across specific Asian subgroups. Between 2000 and 2010, the Asian Indian population grew the fastest, by 68%, followed by the Filipino (45%), Vietnamese (42%), Chinese (40%), and Korean (39%) populations. The Japanese population experienced the slowest growth of all Asian subgroups by 14% only. Even though the top 8 states with the largest Asian populations were covered in our incidence analyses, the fastest Asian American population growth occurred in states with relatively less Asian Americans, such as Nevada, Arizona, and North Carolina. Also, the distribution of Asian American populations varied across the US. Japanese (70%) and Filipinos (66 %) had the two largest proportions that lived in the West. Large proportions of Chinese (49%), Vietnamese (49%) and Koreans (44%) lived in the West as well. A much lower proportion of Asian Indians (25%)

lived in the West compared to the other groups. Larger proportions of Vietnamese (32%), Asian Indians (29 percent), and Koreans (24%) lived in the South. A greater proportion of Asian Indians (30%), Chinese (26 %), and Koreans (21%) lived in the Northeast. The Midwest had the lowest proportion of each Asian subgroup. Therefore, inclusion of cancer registry data from both SEER and NPCR catchment areas is important to produce accurate cancer incidence and survival estimates for specific Asian subgroups.

2. Improve identification of Asian subgroups

The proportion of NOS cases increased rapidly from 1% in 1990 to 15% in 2012 in SEER and is even higher in NPCR. The exclusion of NOS cases underestimates cancer incidence for Asian subgroups. Several methods have been developed to improve the identification of Asian subgroups by reassigning NOS to a specific Asian subgroups, such as NAPIIA and the stratified imputation proposed in our study. However, both methods heavily rely on a correct birthplace. Once a cancer patient dies, his/her birthplace will be updated on death certificate. Findings from previous study conducted by Gomez et al. (2004) indicated that accuracy of birthplace information on death certificate is extremely high because the completion of socio-demographic items on death certificate requires assistance from a next-of-kin or a significant other of the deceased. Notably, the availability of birthplace data may not be uniform across Asian subgroups and may introduce new bias in incidence analysis. More important, such methods should be used with caution in survival analysis, because correction by birthplace will raise the proportion of the deceased only. As a result, death cases will be over-represented and survival estimates will be underestimated. Race/ethnicity data from cancer registries are derived from medical records and administrative information. The ultimate way to diminish NOS cases is to raise the awareness in healthcare providers of collecting additional information on Asian ethnicity when an Asian patient is admitted.

Census allows respondents to report multiple races. For each specific Asian group, four different scenarios are produced to enumerate population data: (1) Asian alone with only one specific Asian group reported, (2) Asian alone with two or more specific Asian groups reported, (3) Asian in combination with non-Asian race(s) with only one specific Asian group reported, and (4) Asian in combination with non-Asian race(s) with two or more specific Asian groups reported. To simplify Census's 4-scenario method, SEER tabulates two population values: Asian alone (scenario 1) and Asian alone or in combination (scenario 1-4 combined). Census population data are tallies of the number of Asian responses rather than the number of Asian respondents. Gomez et al. proposed a simple algorithm to calculate Asian-group specific population denominators by averaging the two SEER values. However, their method cannot fully eliminate the inflation from respondents reporting three or more specific Asian groups. In the present study, a bridging method was applied to adjust for inflation caused by repeated counts from those reporting multiple Asian races. With the growing multiracial population, further research is required to examine the impact of multiracial Asians on cancer incidence and survival disparities.

3. Impact of nativity on cancer incidence and survival in Asian Americans

Studies have shown that cancer incidence and survival vary considerably between foreign-born and US-born Asian Americans because health in immigrant populations tends to differ from that of non-immigrants due to the maintenance of traditional cultural behaviors, the immigration experience itself, and the characteristics of individuals who choose to migrate. Unfortunately, neither information on birthplace nor length of stay in US is routinely collected by cancer registries. Statistical approach has been developed by researchers in California to differentiate foreign-born and US-born individuals using patient's age at receiving a social security number. However, this method has not been validated in any state other than California. Continued research is needed to

more accurately assess the impact of nativity or length of stay in US of Asian Americans on their cancer incidence and survival disparities.

4. Measure the awareness and usage of cancer screening and prevention in Asian Americans

Asian Americans are disproportionately affected by infection-related cancers. Most of these cancers can be prevented by immunization or detected at early stage by screening. Assessing and improving screening and prevention participation in Asian Americans is a key focus of research. The National Health Interview Survey carries out annual assessments of self-reported adherence to US Preventive Services Task Force screening recommendations. There is evidence for racial or ethnic disparities in screening and prevention participation. However, these survey data aggregate specific Asian subgroups into one single groups. Understanding and tackling ethnic disparities in awareness and usage of cancer screening and prevention among Asian subgroups should be a key issue for future research. Overall, there is an urgent need for research aimed at measuring the different patterns of screening and vaccination behaviors among Asian Americans to inform the development of interventions to address these inequalities.

In conclusion, continued research is needed to more accurately assess the cancer incidence and survival disparities among the Asian American population. In order to realize the goal of elimination of cancer health disparities, it remains essential that the future public health professionals contributes to the current body of knowledge on this subject and encourages public health practice and policy to become aligned with the research.

Appendix 1

UNLV
UNIVERSITY OF NEVADA LAS VEGAS

Biomedical IRB – Exempt Review
Deemed Exempt

DATE: February 25, 2014

TO: **Dr. Paulo Pinheiro,** Environmental & Occupational Health

FROM: Office of Research Integrity – Human Subjects

RE: Notification of IRB Action
Protocol Title: Cancer among Asian American Populations in the United States: Incidence and Survival Disparities.
Protocol # 1402-4721M

This memorandum is notification that the project referenced above has been reviewed as indicated in Federal regulatory statutes 45CFR46 and deemed exempt under 45 CFR 46.101(b)4.

Any changes to the application may cause this project to require a different level of IRB review. Should any changes need to be made, please submit a **Modification Form**. When the above-referenced project has been completed, please submit a **Continuing Review/Progress Completion report** to notify ORI – HS of its closure.

If you have questions or require any assistance, please contact the Office of Research Integrity - Human Subjects at IRB@unlv.edu or call 895-2794.

Office of Research Integrity – Human Subjects
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(702) 895-2794 • FAX: (702) 895-0805

Appendix 2

UNLV
UNIVERSITY OF NEVADA LAS VEGAS

Biomedical IRB – Exempt Review
Deemed Exempt

DATE: March 12, 2014

TO: **Dr. Paulo Pinheiro,** Environmental & Occupational Health

FROM: Office of Research Integrity – Human Subjects

RE: Notification of IRB Action
Protocol Title: Cancer Incidence and Survival Disparities among Hispanics and Asian Americans in the United States
Protocol # 1403-4754M

This memorandum is notification that the project referenced above has been reviewed as indicated in Federal regulatory statutes 45CFR46 and deemed exempt under 45 CFR 46.101(b)2.

Any changes to the application may cause this project to require a different level of IRB review. Should any changes need to be made, please submit a **Modification Form**. When the above-referenced project has been completed, please submit a **Continuing Review/Progress Completion report** to notify ORI – HS of its closure.

If you have questions or require any assistance, please contact the Office of Research Integrity - Human Subjects at IRB@unlv.edu or call 895-2794.

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Yuan, J. M. (2013). Cancer prevention by green tea: evidence from epidemiologic studies. *The American Journal of Clinical Nutrition, 6 Supplement,* 1676S-1681S.

Curriculum Vitae

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Education

2016	University of Nevada, Las Vegas	Doctor of Public Health, Epidemiology and Biostatistics
2012	University of Nevada, Las Vegas	Master of Public Health, Epidemiology and Biostatistics
2006	Shanghai Jiao Tong University	Bachelor of Science in Nursing

Professional Experience

2013–Current	University of Nevada, Las Vegas	Research Assistant *School of Community Health Sciences & School of Life Sciences*
2013–Current	University of Nevada, Las Vegas	Vice President *Public Health Student Association*
2011–2013	University of Nevada, Las Vegas	Research Assistant *School of Nursing*
2011–2012	University of Nevada, Las Vegas	Research Assistant *School of Community Health Sciences*
2011–2012	University of Nevada, Las Vegas	Intern *Student Wellness Zone*
2006–2010	Shanghai Rui Jin Hospital, China	Staff Nurse *Burn Center, ICU, and Blood Purification Center*

Teaching Experience

2015/10/06	University of Nevada, Las Vegas	Instructor *Quasi-Experimental Designs; Screening and Properties of a Test: Sensitivity and Specificity EAB 705*
2015/05/01	Desert Rose Adult High School	Lecturer *Aeroallergen Sampling and Identification*

2015/04/18	Rebel STEM Academy	Lecturer *Aeroallergen Sampling and Identification*
2014/12/11	West Career & Technology Academy	Lecturer *Introduction to Pollen Identification*
2011–2012	University of Nevada, Las Vegas	Teaching Assistant *Biostatistical Methods for the Health Sciences EAB 703*

Credentials and Certifications

2014	AAAAI, US	Certified National Allergy Bureau Pollen & Mold Counter
2010	State of New York, US	Registered Nurse
2006	China	Registered Nurse

Awards and Honors

2016	Emeritas Professor Michelle Chino Award
2015	Western Users of SAS Software Student Scholarship
2015	UNLV Graduate Student Leadership Award
2015	UNLV GPSA Research Sponsorship
2015	UNLV SCHS Dissertation Enhancement Grant
2014	UNLV Public Health Scholarship
2014	UNLV Graduate Student Leadership Award
2012-2013	UNLV Member of Honor Society of Phi Kappa Phi
2012	UNLV James F. Adams/GPSA Scholarship
2011-2016	UNLV Graduate Assess Grant

Publications

2016	Jin H, Pinheiro PS, Xu J, Amei A. Cancer incidence among Asian American populations in the United States, 2009-2011. Int J Cancer 2016; 138: 2136-2145.
	Jin H, Patel T, Buttner MP, Bazylinski D, Seggev JS. Seasonal tree, weed and grass pollen patterns in the Las Vegas Valley. J Allergy Clin Immunol 2016; 137: AB123.
2015	Pinheiro PS, Jin H. No increased risk for mesothelioma in relation to natural-occurring asbestos in Southern Nevada. J Thorac Oncol 2015; 10: e64-65.

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2014 Benyshek DC, Kachinski JJ, Jin H. Maternal (F0) prenatal/lactation diets varying in saturated fat and long-chain polyunsaturated fatty acids alters the insulin sensitivity of F1 Sprague Dawley rats fed a high saturated-fat western diet postweaning. Open J Endocr Metab Dis 2014; 4: 245-252.

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Pinheiro PS, Bungum TJ, Jin H. Limitations in the imputation strategy to handle missing nativity data in the Surveillance, Epidemiology, and End Results Program. Cancer 2014; 120: 3261-3262.

2013 Jin H, Benyshek DC. The "metabolic syndrome index": A novel, comprehensive method for evaluating the efficacy of diabetes prevention programs. J Diabetes Mellitus 2013; 3: 96-99.

Benyshek DC, Chino M, Dodge-Francis C, Begay TO, Jin H, Giordano C. Prevention of Type 2 Diabetes in Urban American Indian/Alaska Natives Communities: the Life in BALANCE Pilot Study. J Diabetes Mellitus 2013; 3: 194-191.

Presentations

2016 American College of Allergy Asthma & Immunology Annual Meeting
Los Angeles Jin H, Patel T, Buttner MP, Bazylinski D, Seggev JS
USA Seasonal tree, weed and grass pollen patterns in the Las Vegas Valley

2015 Eighth AACR Conference on the Science of Cancer Health Disparities in
Atlanta Racial/Ethnic Minorities and the Medically Underserved
USA Jin H, Pinheiro PS, Xu J, Amei A
Cancer incidence disparities among the Asian American population

2015 Eighth AACR Conference on the Science of Cancer Health Disparities in
Atlanta Racial/Ethnic Minorities and the Medically Underserved
USA Pinheiro PS, Jin H, Cvijetic N, Kelly R, Ponce C, Kobetz E
Breast cancer survival in Nevada: disparities for Filipino and Black women; In-state disadvantage for Las Vegas

2015	American College of Allergy Asthma & Immunology Annual Meeting
San Antonio	Patel T, Jin H, Buttner MP, Bazylinski D, Seggev JS
USA	Mulberry and olive pollen in Las Vegas
2015	International Association of Cancer Registries Annual Meeting
Mumbai	Jin H, Pinheiro PS, Xu J, Amei A
India	Cancer incidence in Asian Americans, 2009-2011
2015	NIH IDeA Western Regional Conference
Coeur d'Alene	Pinheiro PS, Jin H, Cvijetic N, Kelly R
USA	Breast cancer survival disparities in Nevada – a disadvantage for Las Vegas
2015	American Academy of Allergy Asthma & Immunology Annual Meeting
Houston	Jin H, Patel T, Buttner MP, Bazylinski D, Seggev JS
USA	Mulberry - A chronic pollen offender in Las Vegas
2014	Nevada Cancer Control Summit
Las Vegas	Jin H, Pinheiro PS
USA	The effects of tumor thickness and ulceration status on melanoma survival in Nevada
	First place in poster session
2013	Nevada Public Health Association Annual Conference
Reno	Jin H, Pinheiro PS
USA	The effects of tumor thickness and ulceration status on melanoma survival in Nevada
2012	UNLV Graduate & Professional Student Association Research Forum
Las Vegas	Jin H, Schneider BS
USA	Characteristics of leukocyte infiltration in murine soleus muscle after closed crush injury
2012	UNLV MPH Internship Poster Day
Las Vegas	Jin H, Ching M
USA	Barriers to utilization of wellness programs and services in UNLV minority and international students