Cancer Mortality Disparities among Asian American and Native Hawaiian/Pacific Islander Populations in California

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ABSTRACT

Background: Asian American and Native Hawaiian/Pacific Islanders (AANHPI) are the fastest growing minority in the United States. Cancer is the leading cause of death for AANHPIs, despite relatively lower cancer morbidity and mortality. Their recent demographic growth facilitates a detailed identification of AANHPI populations with higher cancer risk.

Methods: Age-adjusted, sex-stratified, site-specific cancer mortality rates from California for 2012 to 2017 were computed for AANHPI groups: Chinese, Filipino, South Asian, Vietnamese, Korean, Japanese, Southeast Asian (i.e., Cambodian, Hmong, Laotian, Thai), and Native Hawaiian and Other Pacific Islander (NHOPI). Regression-derived mortality rate ratios (MRR) were used to compare each AANHPI group to non-Hispanic whites (NHW).

Results: AANHPI men and women (total 40,740 deaths) had lower all-sites-combined cancer mortality rates (128.3 and 92.4 per 100,000, respectively) than NHWs (185.3 and 140.6) but higher mortality for nasopharynx, stomach, and liver cancers. Among AANHPIs, both NHOPIs and Southeast Asians had the highest overall rates including for colorectal, lung (men only), and cervical cancers; South Asians had the lowest. NHOPI women had 41% higher overall mortality than NHWs (MRR = 1.41; 95% CI, 1.25–1.58), including for breast (MRR = 1.33; 95% CI, 1.08–1.65) and markedly higher for endometrial cancer (MRR = 3.34; 95% CI, 2.53–4.42).

Conclusions: AANHPI populations present with considerable heterogeneous cancer mortality patterns. Heightened mortality for infection, obesity, and tobacco-related cancers in Southeast Asians and NHOPI populations highlight the need for differentiated priorities and public health interventions among specific AANHPI populations.

Impact: Not all AANHPIs have favorable cancer profiles. It is imperative to expand the focus on the currently understudied populations that bear a disproportionate cancer burden.

Introduction

Asian American and Native Hawaiian/Pacific Islanders (AANHPI) are 24.7 million and account for 6% of the United States population (1, 2). As the fastest growing major racial/ethnic group, AANHPIs are projected to comprise 10% of the US population by 2060 (1, 3). At times described as the "model minority," AANHPIs, in aggregate, have relatively favorable socioeconomic and health profiles (4). Notwithstanding, cancer has been the leading cause of death for AANHPIs since the year 2000 (5). As immigration increases (1) and the older population expands (6), the AANHPI cancer burden will increase concomitantly.

With ancestry in numerous countries of origin, remarkable heterogeneity exists within the AANHPI designation. The six largest groups among AANHPI are Chinese, South Asian, Filipino, Vietnamese, Korean, and Japanese (1) followed by the less commonly studied Native Hawaiian and Other Pacific Islander (NHOPI) population (7). Differences in culture, nativity, migration history, English language proficiency, dietary practices, educational attainment, occupation type, and other factors impact their overall health as well as cancer-specific risk factors (8–13). As such, researchers have been advocating for the presentation of cancer indicators by unique racial group for AANHPIs (14–18).

Cancer mortality is a population-based indicator that reflects both cancer incidence and survival. Importantly, for states that provide birthplace information along with detailed race for decedents upon request, mortality data are uniquely suited for accurate disaggregation (19) into AANHPI-specific group, minimizing misclassification and without the need for imputation (20). In this study, we aim to characterize the most recent cancer mortality patterns (2012–2017) across major cancer sites for AANHPI groups residing in California, home to one-third of all AANHPIs in the US. By using the same geographical area, the study avoids potential bias by region. Notably, in addition to the six largest AANHPI groups often studied, we include two growing populations often excluded in mortality studies that disaggregate AANHPIs due to relatively fewer cancer deaths: Southeast Asian (grouping Cambodian, Hmong, Laotian, and Thai) and NHOPIs. These exclusions obfuscate their unique cancer challenges.

Materials and Methods

Six years of complete cancer mortality data, from January 1, 2012, to December 31, 2017, were obtained from the California Department of Public Health. Age, sex, education level, race/ethnicity, birthplace, and

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Note: Supplementary data for this article are available at Cancer Epidemiology, Biomarkers & Prevention Online (http://cebp.aacrjournals.org/).

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underlying cause of death of the decedent were examined. Included decedents were California residents whose primary cause of death was any malignant neoplasm, inclusive of ICD-10 codes C00-C97 (21). All-sites-combined cancer deaths were analyzed, as well as 19 of the most common cancer sites.

Cancer mortality rates were examined for the majority non-Hispanic White (NHW) population, as well as for the AANHPI population in aggregate and eight distinct groups: Chinese, Filipino, South Asian, Vietnamese, Korean, Japanese, Southeast Asian, and NHOPI. The combined AANHPI population included all aforementioned detailed racial groups as well as decedents from other specified AANHPI ($n = 266$; 0.1%) and unspecified AANHPIs ($n = 500$; 1.2%). South Asians included decedents of Indian race primarily from India but also other from countries (United States, Fiji, Kenya, etc.), in addition to decedents from Pakistan, Nepal, Bangladesh, and Sri Lanka as categorized in previous studies (22). Southeast Asians included primarily Cambodian, Laotian, Hmong, and Thai decedents. NHOPI included Samoan, Native Hawaiian, Guamanian, Tongan, and Fijian decedents, as well as those from any other Polynesian, Micronesian, and Melanesian islands and nations. Multiple-race AANHPI (e.g., Chinese-Cambodian or Filipino-Hawaiian) decedents were assigned according to primary race reported (Race 1) following the practice of previous population-based studies (23, 24). These subjects constituted only a small proportion of all AANHPIs in this study ($n = 1,271$; 3.1%). Multiracial AANHPIs that reported non-AANHPI races (i.e., White, Black, American Indian) were excluded ($n = 1,323$).

Population denominators were obtained from the US Census Bureau, using 2012 to 2017 pooled single-year American Community Survey data (**Table 1**; ref. 25). For the six-year period, cancer mortality rates were calculated per 100,000 persons, sex-stratified, annualized, and age-standardized to the 2000 US Standard Population (**Tables 2** and **3**). Eighteen 5-year age-group bands (except the last; 85 and older) were used; 95% confidence intervals were calculated using Gamma intervals modification (26). For South Asian, Southeast Asian, and NHOPI specific subgroups (e.g., Nepalese, Thai, Samoan) with small numbers of cancer deaths and small population sizes, rates could be less reliable and therefore heterogeneity by cancer site was presented as proportions of cancer deaths only (Supplementary Tables S1 and S2).

For direct comparisons of mortality rates, we computed sex-stratified, age-adjusted, cancer site-specific mortality rate ratios (MRR) using negative binomial regression (27), which is more effective than the US Standard population weights in combining age-specific ratios of populations with distinct age structures. Decedents ages 35 and older were included in the models, except for prostate cancer, which included ages 45 and older (**Table 4**).

SAS 9.4 was used for data analyses. Institutional Review Board approval was obtained from the California Department of Public Health.

Results

A total of 260,914 cancer deaths in California from 2012 to 2017 were analyzed: 84% among NHWs and 16% among AANHPI (**Table 1**). Among AANHPI decedents, the largest represented groups were Chinese and Filipino, with 12,101 and 10,032 cancer deaths, respectively, in the 6-year period. Considerable sociodemographic heterogeneity was evident as shown in **Table 1**. The proportion of college-educated decedents was slightly lower among AANHPIs (53%) than NHWs (55%). However, tremendous variation existed by distinct AANHPI group, ranging from 71% among Filipinos to 27% among Southeast Asians. Among each AANHPI group, over 90% of cases were foreign-born, with the exception of NHOPI with 65% (partly due to inclusion of Native Hawaiians in this group) and Japanese with only 37% (**Table 1**).

Among NHW and AANHPI men in aggregate, the top cause of cancer death (computed as a percent of total cancer deaths) was lung cancer, with colorectal, liver, pancreas, and prostate cancers also in the top five for both groups. By distinct AANHPI group, lung cancer was still the leading cause of cancer mortality, accounting for 16% to 29% of cancer deaths, along with colorectal and pancreas cancers which ranked in the top five. Liver cancer, accounting for 9% to 21% of all cancer deaths depending upon the group, was either the second or third leading cause of death for all AANHPI races except Japanese. Prostate cancer did not rank in the top five for Vietnamese, Koreans, or Southeast Asians. Stomach cancer, ranking only 14th for NHWs, was fourth or fifth for Japanese, Korean, and Vietnamese men. In addition, oral cancer was the fifth leading cause of cancer mortality for Southeast Asian men (**Table 2**). Among groups that represent more than one country of origin (i.e., South Asians, Southeast Asians, and NHOPI), there was considerable within group heterogeneity in the proportion of deaths by cancer type (Supplementary Tables S1 and S2).

Among women, lung and breast were leading causes, accounting for almost half of all cancer deaths among NHW women. For AANHPI women, in aggregate and for each group, lung and breast accounted for

Table 1. Study population characteristics. California, 2012–2017.

	Population Data, CA 2012–2017			Cancer Deaths, CA 2012–2017		
	Annualized *N*[a]	Proportion of total U.S. population residing in CA	Median age (among those over 20)	Number	% At least some college	% Foreign-born
NHW	14,752,057	7.5	50	220,174	55.3	11.4
AANHPI-All	6,221,713	29.6	44	40,740	52.7	86.1
Chinese	1,538,099	35.8	46	12,101	46.7	90.3
Filipino	1,396,110	42.2	45	10,032	70.9	92.6
South Asian	823,840	18.3	38	2,206	57.0	97.0
Vietnamese	695,249	36.7	45	4,257	36.2	98.3
Korean	504,225	30.1	44	3,848	54.9	97.4
Japanese	375,903	32.7	50	4,233	54.4	37.1
Southeast Asian	305,721	33.0	37	1,850	27.1	98.5
NHOPI	191,998	25.5	40	1,447	39.0	65.0

[a]Ordered from largest to smallest annualized *N*.

Table 2. Selected site-specific age-adjusted[a] cancer mortality rates per 100,000 by detailed race group. Male. California 2012–2017.

	NHW		AANHPI[b]		Chinese		Filipino		South Asian		Vietnamese		Korean		Japanese		Southeast Asian		NHOPI	
	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)	*n*	Rate (95% CI)	*n*	Rate (95% CI)
Oral cavity and pharynx	2,950	4.6 (4.4–4.8)	582	3.4 (3.1–3.7)	227	4.4 (3.9–5.1)	96	2.6 (2.1–3.2)	45	2.9 (2.0–3.9)	70	3.3 (2.5–4.2)	25	1.8 (1.2–2.7)	38	2.7 (1.9–3.7)	43	6.3 (4.4–8.7)	24	5.7 (3.6–8.7)
Nasopharynx only	178	0.3 (0.2–0.3)	282	1.5 (1.4–1.7)	145	2.9 (2.4–3.4)	41	1.0 (0.7–1.4)	[c]	[c]	36	1.6 (1.1–2.2)	[c]	[c]	[c]	[c]	31	4.4 (2.9–6.4)	[c]	[c]
Esophageal	4,528	7 (6.9–7.3)	460	3 (2.5–3.0)	111	2 (1.7–2.5)	99	2 (2.0–3.0)	43	3 (2.0–3.8)	48	2 (1.8–3.3)	39	3 (2.0–3.9)	70	5 (3.8–6.3)	17	3 (1.6–4.7)	21	3 (3.2–8.4)
Stomach	2,200	3.6 (3.4–3.7)	1,104	7.0 (6.5–7.4)	382	7.5 (6.8–8.3)	133	3.8 (3.2–4.6)	28	1.8 (1.1–2.7)	117	6.0 (4.9–7.2)	212	15.9 (13.8–18.2)	154	10.9 (9.2–12.9)	31	6.0 (3.9–8.7)	22	5.8 (3.5–8.9)
Colorectal	9,285	15.1 (14.8–15.4)	2,120	12.9 (12.3–13.5)	663	13.0 (12.0–14.1)	470	12.8 (11.6–14.1)	96	6.1 (4.8–7.5)	229	11.6 (10.1–13.3)	241	17.5 (15.3–19.9)	189	13.2 (11.3–15.4)	116	20.2 (16.3–24.6)	75	19.0 (14.6–24.1)
Liver	5,724	8.6 (8.4–8.8)	2,540	15.1 (14.5–15.7)	756	14.6 (13.6–15.7)	451	12.4 (11.2–13.6)	98	6.2 (5.0–7.7)	535	25.9 (23.7–28.2)	303	21.7 (19.3–24.4)	100	6.7 (5.4–8.3)	197	32.0 (27.2–37.2)	65	14.5 (11.0–18.8)
Pancreas	8,210	13.0 (12.7–13.3)	1,466	9.1 (8.6–9.5)	489	9.5 (8.6–10.4)	309	8.4 (7.4–9.4)	79	5.0 (3.9–6.3)	123	6.3 (5.2–7.6)	174	12.7 (10.9–14.8)	171	11.8 (10.1–13.8)	52	9.6 (6.9–13.0)	37	9.8 (6.7–13.8)
Lung	25,032	39.9 (39.4–40.4)	5,238	32.8 (31.9–33.7)	1,664	32.6 (31.0–34.2)	1,308	37.8 (35.7–40.0)	186	12.3 (10.4–14.3)	732	37.6 (34.8–40.5)	486	36.7 (33.4–40.2)	400	28.2 (25.4–31.2)	238	48.5 (41.9–55.7)	155	44.3 (37.0–52.4)
Prostate	12,887	21.2 (20.8–21.5)	1,389	9.7 (9.2–10.2)	371	7.4 (6.7–8.2)	443	15.5 (14.0–17.1)	116	9.6 (7.8–11.6)	77	4.7 (3.7–5.9)	76	6.6 (5.1–8.3)	181	11.2 (9.6–13.1)	41	9.6 (6.7–13.2)	55	21.8 (16.2–28.4)
Kidney	3,256	5.2 (5.0–5.4)	522	3.2 (2.9–3.5)	124	2.4 (2.0–2.9)	158	4.2 (3.6–5.0)	41	2.5 (1.7–3.4)	49	2.3 (1.7–3.0)	59	4.3 (3.3–5.6)	58	4.1 (3.1–5.4)	[c]	[c]	[c]	[c]
Bladder	5,376	8.8 (8.6–9.0)	469	3.2 (2.9–3.5)	145	2.9 (2.5–3.5)	91	3 (2.4–3.8)	36	2.6 (1.8–3.6)	34	1.9 (1.3–2.7)	62	5 (3.8–6.4)	71	4.7 (3.7–6.0)	[c]	[c]	[c]	[c]
Brain	4,134	6.9 (6.7–7.1)	498	3 (2.7–3.2)	139	2.9 (2.4–3.4)	118	3.1 (2.6–3.8)	53	2.6 (1.9–3.5)	58	3 (2.3–3.9)	45	3.5 (2.5–4.7)	35	2.6 (1.8–3.7)	20	3.2 (1.9–5.1)	18	3.7 (2.1–5.9)
NHL	4,515	7.4 (7.2–7.6)	834	5.3 (4.9–5.7)	252	5.0 (4.4–5.7)	211	6.2 (5.4–7.2)	59	3.9 (2.9–5.1)	86	4.6 (3.7–5.8)	54	4.0 (3.0–5.3)	101	6.7 (5.4–8.3)	42	7.6 (5.2–10.5)	17	4.5 (2.4–7.4)
Leukemia	5,450	9.2 (8.9–9.4)	799	5.1 (4.7–5.5)	222	4.6 (4.5-0.2.0)	238	7.0 (6.1–8.0)	65	4.1 (3.1–5.3)	101	5.7 (4.6–6.9)	45	3.4 (2.5–4.6)	57	4.1 (3.1–5.4)	29	4.8 (3.1–7.1)	26	6.7 (4.2–10.1)
All-sites-combined[d]	114,853	185.3 (184.2–186.4)	20,622	128.3 (126.5–130.1)	6,288	123.6 (120.6–126.8)	4,772	138.2 (134.1–142.3)	1,153	75.2 (70.6–80.1)	2,528	129.3 (124.2–134.7)	2,051	153.1 (146.3–160)	1,860	128.5 (122.5–134.7)	969	176.3 (164.1–189.1)	640	174.9 (160.4–190.2)

Abbreviation: NHL, non-Hodgkin lymphoma.
[a]Age-adjusted to the 2000 U.S. Standard Population.
[b]Includes all groups, not only those detailed here.
[c]Not reported; rate calculated from observations fewer than 13.
[d]All-sites-combined includes those listed as well as all others not detailed.

27% to 35% of all cancer deaths. Colorectal and pancreas were also in the top five leading causes for all analyzed groups. Liver cancer ranked only tenth among NHW women but was the fifth leading cause of cancer death for AANHPI women in aggregate, the third leading cause among Southeast Asian women, fourth for Vietnamese, and fifth for Chinese. Stomach cancer was the fifth leading cause of cancer death among Korean and Japanese women; ovarian cancer was second for South Asians and fifth for Filipinas. Among NHOPI women, endometrial cancer ranked as their fourth leading cause, accounting for 9% of all cancer deaths (**Table 3**).

In aggregate, AANHPI men and women had lower all-sites-combined cancer mortality rates per 100,000 (128.3, 95% CI, 126.5–130.1; 92.4, 95% CI, 91.1–93.7, respectively) than NHWs (185.3, 95% CI, 184.2–186.4; 140.6, 95% CI, 139.7–141.5, respectively). Among all analyzed AANHPI groups, the highest all-sites-combined cancer mortality rates were seen among NHOPI and Southeast Asian men (174.9, 95% CI, 160.4–190.2; 176.3, 95% CI, 164.1–189.1, respectively; **Table 2**) and women (177.3, 95% CI, 164.4–190.9; 112.3, 95% CI, 104.8–120.5, respectively; **Table 3**); South Asians had the lowest (75.2, 95% CI, 70.6–80.1 in males; 65.9, 95% CI, 61.8–71.2 in females). AANHPI men and women had lower cancer mortality than NHWs for most analyzed cancers, with the exception of the cancers associated with infections: stomach, liver, nasopharynx, and cervical. Among both men and women, the highest stomach cancer rates were among Koreans. Southeast Asian, Vietnamese, and Korean men and women had the highest liver cancer rates. Nasopharynx cancer mortality rates were highest among Southeast Asian men and Chinese women. The highest cervical cancer mortality was among NHOPI and Southeast Asian women.

Comparisons with the NHW reference group showed lower all-sites combined cancer mortality for AANHPIs in aggregate (male MRR = 0.70, 95% CI, 0.69–0.72; female MRR = 0.68, 95% CI, 0.61–0.75) and the majority of AANHPI groups. AANHPIs had significantly higher nasopharynx, stomach, and liver cancer mortality compared with NHWs (Supplementary Table S3). Examined by distinct group, no significant differences in overall mortality were found between Southeast Asians (both sexes) and NHOPI men compared with NHWs. NHOPI women had a 41% greater overall cancer mortality than their NHW counterparts (MRR = 1.41, 95% CI, 1.25–1.58). By cancer site, Southeast Asian men and women had the greatest mortality for oral cavity and pharynx (1.6 and 2.1 times greater, respectively) and liver cancer (4.4 and 3.3 times higher). Southeast Asian men also had higher mortality for colorectal and lung cancer (MRR = 1.46, 95% CI, 1.21–1.76; MRR 1.27, 95% CI, 1.06–1.51, respectively) compared with NHW men. Further, NHOPI women had higher colorectal, breast, cervical, and endometrial cancer mortality compared with NHW women, 1.5, 1.3, 7.1, and 3.3 times higher, respectively. Likewise, Korean men and women had greater stomach cancer mortality, with rates 4.4 and 5.2 times higher, respectively, than NHWs (**Table 4**). Key findings are summarized in **Table 5**.

Discussion

To our knowledge, this study represents the most recent population-based analysis of cancer data on the fastest growing minority group in the US. AANHPIs in California had lower all-combined rates for most cancers including the four main sites, prostate, breast, colorectal, and lung, but uniformly higher mortality rates for liver and stomach cancers in each AANHPI group except South Asians. The liver cancer excess mortality among AANHPIs (28) has been attributed to the high prevalence of chronic infection by Hepatitis B among AANHPI populations. As previously established (28), the low mortality observed among South Asian and Japanese males is in contrast to the very high rates for Vietnamese. In this study, we found that rates for Southeast Asians, originally from the same geographic region, actually exceeded those of Vietnamese in the US. Overall, our results are consistent with previous mortality studies (5, 29–33) and mirror the relative differences in AANHPI populations found in previous incidence reports (5, 22, 30, 32–35). Moreover, our findings parallel those observed for AANHPI in other states with large proportions of these populations, such as Hawaii (36). Previously observed excess burden for some specific cancer sites, including very high rates for nasopharynx among Chinese, stomach for Koreans, and liver for Vietnamese (22), persisted in the recent period (2012–2017) studied here.

In this study, we further update and expand on previously reported mortality data for two often overlooked and understudied AANHPI groups with distinct, unfavorable patterns, even for noninfection related cancers: NHOPIs and Southeast Asians, for which an excess mortality burden has been documented (5, 30). These two groups had the highest cancer mortality rates of all the AANHPI groups, particularly high for NHOPI females.

The Southeast Asian group is itself comprised of heterogeneous populations, including Laotians, Hmong, Cambodians, and Thais. Combined, they represent a relatively small US population, approximately 1.6 million (2), whose specific needs may be overlooked when grouped with the more favorable cancer mortality profiles of other more populous AANHPI groups such as Chinese and South Asians. This conceals their specific cancer vulnerabilities: overall cancer mortality rates were quite high compared with other AANHPI groups, particularly for lung and oral cancers. Except for Thais, Southeast Asians (i.e., Cambodians, Hmong, and Laotians) have been documented with the lowest educational attainment among all Asian subgroups in the US (4), which has been shown to be associated with a higher risk of cancer death for nearly all cancers (37). This disparity along with the high poverty rates observed for these populations (4) may further influence cancer mortality disparities due to smoking, obesity, physical inactivity, diet, alcohol use, screening, and treatment (38). Given the documented high prevalence of tobacco use, both smoked and smokeless (e.g., chewing), among Southeast Asian men and women (39, 40) the excessive lung and oral cancer mortality rates are not entirely surprising. In this respect, further investigation into the types and frequency of tobacco use as well as the efficacy of existing smoking cessation programs and other interventions are warranted. Moreover, the high mortality for both colorectal and cervical cancer among Southeast Asians suggests they could benefit from more culturally specific approaches to existing cancer screening programs. High liver cancer mortality among Southeast Asians highlights the persistent need for Hepatitis B testing/screening in all AANHPI populations but particularly those consisting of more recent immigrants. Targeted public health interventions may be of particular benefit to this group.

Similarly to Southeast Asians, the NHOPI population of approximately 1.5 million is relatively small (2) but nonetheless of importance in disentangling AANHPI cancer mortality disparities. Among AANHPI groups, NHOPI men had relatively high cancer mortality rates, but it is among females that this excess is particularly worrying as they have very high rates, not only higher in comparison to other AANHPI groups but also in relation to NHWs. Uniquely, all-sites-combined cancer mortality for NHOPIs was similar among men and women. This unusual pattern, rarely seen in any racial/ethnic group,

Table 3. Selected site-specific age-adjusted[a] cancer mortality rates per 100,000 by detailed race group. Female. California 2012–2017.

	NHW		AANHPI[b]		Chinese		Filipino		South Asian		Vietnamese		Korean		Japanese		Southeast Asian		NHOPI	
	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)	*n*	Rate (95% CI)	*n*	Rate (95% CI)
Oral cavity and pharynx	1,170	1.6 (1.5–1.6)	264	1.2 (1.1–1.4)	89	1.4 (1.1–1.7)	70	1.2 (1.0–1.6)	[c]	[c]	25	1.1 (0.7–1.6)	13	0.7 (0.4–1.3)	21	0.7 (0.4–1.2)	25	3.3 (2.1–4.9)	[c]	[c]
Nasopharynx only	60	0.1 (0.1–0.1)	102	0.5 (0.4–0.6)	51	0.8 (0.6–1.1)	23	0.4 (0.3–0.6)	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]
Esophageal	1,214	1.6 (1.5–1.7)	137	0.6 (0.5–0.7)	40	0.6 (0.4–0.8)	18	0.3 (0.2–0.5)	22	1.4 (0.9–2.2)	[c]	[c]	[c]	[c]	33	1.4 (0.9–2.1)	[c]	[c]	[c]	[c]
Stomach	1,297	1.7 (1.6–1.8)	985	4.5 (4.3–4.8)	331	5.2 (4.6–5.8)	122	2.1 (1.8–2.6)	27	1.7 (1.1–2.5)	93	0.3 (0.1–0.7)	170	9.0 (7.7–10.5)	144	5.2 (4.3–6.3)	42	5.7 (4.1–7.8)	34	8.1 (5.5–11.5)
Colorectal	9,034	11.8 (11.5–12.0)	2,010	9.2 (8.8–9.6)	585	9.0 (8.3–9.8)	450	8.0 (7.3–8.8)	70	4.8 (3.7–6.2)	194	8.5 (7.3–9.8)	210	11.0 (9.5–12.6)	281	10.4 (9.1–11.9)	116	15.1 (12.4–18.3)	73	17.2 (13.3–21.9)
Liver	2,820	3.7 (3.6–3.8)	1,311	6.1 (5.7–6.4)	347	5.4 (4.8–6.0)	302	5.5 (4.8–6.1)	46	2.7 (1.9–3.6)	179	8.6 (7.4–10.0)	159	8.5 (7.2–9.9)	135	5.4 (4.4–6.5)	87	11.1 (8.8–13.8)	28	6.4 (4.1–9.4)
Pancreas	7,541	9.7 (9.5–9.9)	1,658	7.7 (7.3–8.1)	467	7.4 (6.7–8.1)	420	7.4 (6.7–8.2)	65	4.6 (3.6–5.9)	116	5.3 (4.3–6.3)	199	10.7 (9.2–12.3)	260	10.2 (8.9–11.7)	65	8.3 (6.3–10.6)	42	10.8 (7.6–14.7)
Lung	24,841	32.7 (32.3–33.2)	3,730	17.2 (16.6–17.7)	1,327	20.8 (19.7–22.0)	851	14.8 (13.8–15.9)	97	6.7 (5.4–8.2)	351	15.8 (14.1–17.6)	276	14.8 (13.1–16.6)	461	18.2 (16.4–20.1)	156	20.4 (17.2–24.0)	141	34.6 (28.8–41.1)
Breast	16,425	22.8 (22.4–23.2)	2,868	12.9 (12.5–13.4)	722	11.3 (10.5–12.2)	945	16.3 (15.3–17.4)	209	12.0 (10.4–13.9)	205	8.6 (7.5–10.0)	186	9.5 (8.1–11.0)	296	13.6 (12.0–15.5)	85	10.1 (8.0–12.5)	146	28.8 (24.0–34.2)
Cervix	683	1.3 (1.2–1.4)	443	2.1 (1.9–2.3)	89	1.5 (1.2–1.8)	132	2.5 (2.1–2.9)	16	1.0 (0.6–1.7)	43	1.9 (1.3–2.5)	34	1.8 (1.2–2.5)	31	1.9 (1.2–2.8)	43	5.3 (3.8–7.2)	41	7.4 (5.3–10.2)
Endometrium	3,717	4.9 (4.8–5.1)	801	3.6 (3.3–3.8)	209	3.3 (2.8–3.7)	281	4.7 (4.1–5.3)	49	2.8 (2.0–3.7)	42	1.7 (1.2–2.4)	49	2.5 (1.8–3.3)	60	2.7 (2.1–3.6)	22	2.9 (1.8–4.4)	73	15.1 (11.6–19.3)
Ovary	5,084	7.3 (7.1–7.5)	1,061	4.8 (4.5–5.1)	272	4.3 (3.8–4.9)	305	5.3 (4.7–5.9)	100	5.9 (4.8–7.2)	94	3.9 (3.1–4.8)	98	5.0 (4.1–6.1)	99	4.5 (3.5–5.6)	37	4.5 (3.1–6.3)	32	5.7 (3.8–8.3)
Kidney	1,629	2.1 (2.0–2.3)	270	1.2 (1.1–1.4)	89	1.4 (1.1–1.7)	72	1.3 (1.0–1.6)	21	1.4 (0.9–2.2)	[c]	[c]	25	1.3 (0.8–1.9)	25	0.9 (0.5–1.4)	[c]	[c]	[c]	[c]
Bladder	1,898	2.3 (2.2–2.4)	193	0.9 (0.7–1.0)	68	1.0 (0.8–1.3)	26	0.5 (0.3–0.7)	[c]	[c]	15	0.7 (0.4–1.2)	22	1.2 (0.8–1.9)	41	1.3 (0.9–1.9)	[c]	[c]	[c]	[c]
Brain	3,048	4.5 (4.3–4.7)	432	2.0 (1.8–2.2)	113	1.9 (1.6–2.3)	112	2.1 (1.7–2.5)	53	2.8 (2.0–3.6)	61	2.8 (2.1–3.6)	25	1.3 (0.9–2.0)	29	1.2 (0.7–1.8)	17	2.4 (1.4–3.9)	15	2.8 (1.5–4.8)
NHL	3,480	4.5 (4.3–4.6)	699	3.3 (3.0–3.5)	204	3.2 (2.8–3.7)	211	3.8 (3.3–4.4)	38	2.8 (2.0–3.8)	44	2.2 (1.5–2.9)	42	2.3 (1.6–3.1)	98	3.4 (2.7–4.3)	25	3.3 (2.1–4.8)	24	5.6 (3.4–8.4)
Leukemia	3,889	5.2 (5.0–5.3)	637	3.0 (2.8–3.3)	177	2.9 (2.4–3.3)	197	3.7 (3.2–4.2)	41	2.4 (1.7–3.3)	65	2.9 (2.2–3.7)	48	2.7 (2.0–3.6)	49	2.2 (1.6–3.0)	28	3.4 (2.2–5.0)	18	3.4 (1.9–5.6)
All-sites-combined[d]	105,321	140.6 (139.7–141.5)	20,118	92.4 (91.1–93.7)	5,813	91.4 (89–93.8)	5,260	92.8 (90.3–95.4)	1,053	65.9 (61.8–70.2)	1,729	77.3 (73.6–81.1)	1,797	95.1 (90.7–99.7)	2,373	95.1 (90.9–99.4)	881	112.5 (104.8–120.5)	807	177.3 (164.4–190.9)

Abbreviation: NHL, non-Hodgkin lymphoma.

[a]Age-adjusted to the 2000 U.S. Standard Population

[b]Includes all groups, not only those detailed here.

[c]Not reported; rate calculated from observations fewer than 13.

[d]All-sites-combined includes those listed as well as all others not detailed.

Table 4. MRRs[a] for selected cancers for NHW, AANHPI, and detailed AANHPI race groups. California, 2012–2017.

	NHW	AANHPI[b]		Chinese		Filipino		South Asian		Vietnamese		Korean		Japanese		Southeast Asian		NHOPI	
Male	**Referent**	**MRR**	**95% CI**	**MRR**	**95% CI**	**MRR**	**95% CI**	**MRR**	**95% CI**	**MRR**	**95% CI**	**MRR**	**95% CI**	**MRR**	**95% CI**	**MRR**	**95% CI**	**MRR**	**95% CI**
Oral cavity and pharynx	1	0.78	(0.68–0.89)	1.07	(0.84–1.36)	0.60	(0.45–0.80)	0.60	(0.43–0.86)	0.82	(0.60–1.11)	0.40	(0.25–0.62)	0.61	(0.42–0.89)	1.62	(1.12–2.34)	1.46	(0.94–2.28)
Nasopharynx only	1	5.38	(4.45–6.51)	9.74	(7.81–12.15)	3.69	(2.63–5.19)	[c]	[c]	5.93	(4.14–8.49)	[c]	[c]	[c]	[c]	16.01	(10.80–23.75)	[c]	[c]
Esophageal	1	0.38	(0.35–0.42)	0.30	(0.25–0.36)	0.37	(0.30–0.45)	0.36	(0.27–0.48)	0.34	(0.26–0.45)	0.39	(0.28–0.53)	0.70	(0.55–0.89)	0.42	(0.26–0.68)	0.80	(0.52–1.23)
Stomach	1	1.91	(1.77–2.07)	2.10	(1.88–2.34)	1.05	(0.87–1.25)	0.48	(0.33–0.70)	1.71	(1.41–2.06)	4.40	(3.82–5.07)	3.05	(2.59–3.59)	1.64	(1.14–2.35)	1.80	(1.18–2.74)
Colorectal	1	0.87	(0.83–0.91)	0.86	(0.8–0.93)	0.89	(0.81–0.98)	0.40	(0.32–0.49)	0.79	(0.69–0.90)	1.18	(1.04–1.34)	0.88	(0.76–1.01)	1.46	(1.21–1.76)	1.39	(1.10–1.75)
Liver	1	2.01	(1.68–2.40)	1.90	(1.55–2.32)	1.55	(1.26–1.91)	0.73	(0.56–0.96)	3.28	(2.68–4.00)	2.71	(2.18–3.37)	0.86	(0.65–1.13)	4.37	(3.44–5.54)	2.05	(1.51–2.80)
Pancreas	1	0.69	(0.65–0.73)	0.73	(0.66–0.80)	0.67	(0.60–0.75)	0.38	(0.30–0.47)	0.49	(0.41–0.59)	0.97	(0.84–1.13)	0.93	(0.80–1.08)	0.75	(0.57–0.99)	0.82	(0.59–1.13)
Lung	1	0.82	(0.79–0.86)	0.87	(0.76–1.00)	0.97	(0.85–1.11)	0.32	(0.27–0.39)	1.10	(0.95–1.28)	0.93	(0.80–1.08)	0.72	(0.61–0.85)	1.27	(1.06–1.51)	1.25	(1.02–1.52)
Prostate	1	0.43	(0.39–0.47)	0.31	(0.26–0.36)	0.68	(0.59–0.78)	0.43	(0.35–0.53)	0.21	(0.17–0.28)	0.28	(0.22–0.36)	0.49	(0.40–0.60)	0.48	(0.35–0.67)	0.94	(0.71–1.25)
Kidney	1	0.61	(0.55–0.67)	0.46	(0.38–0.55)	0.84	(0.72–0.99)	0.49	(0.36–0.67)	0.48	(0.36–0.64)	0.83	(0.64–1.07)	0.79	(0.61–1.02)	[c]	[c]	[c]	[c]
Bladder	1	0.35	(0.32–0.39)	0.32	(0.27–0.38)	0.33	(0.27–0.41)	0.30	(0.21–0.42)	0.23	(0.16–0.32)	0.57	(0.44–0.73)	0.53	(0.42–0.67)	[c]	[c]	[c]	[c]
Brain	1	0.40	(0.36–0.44)	0.38	(0.32–0.46)	0.43	(0.35–0.52)	0.38	(0.28–0.51)	0.39	(0.30–0.52)	0.43	(0.32–0.59)	0.39	(0.28–0.55)	0.42	(0.25–0.68)	0.58	(0.35–0.97)
NHL	1	0.72	(0.67–0.77)	0.67	(0.59–0.76)	0.86	(0.74–0.99)	0.53	(0.41–0.69)	0.63	(0.50–0.78)	0.56	(0.43–0.74)	0.95	(0.78–1.16)	1.19	(0.87–1.61)	0.74	(0.46–1.19)
Leukemia	1	0.55	(0.50–0.60)	0.47	(0.41–0.55)	0.76	(0.65–0.88)	0.44	(0.34–0.58)	0.61	(0.49–0.75)	0.36	(0.27–0.50)	0.45	(0.34–0.59)	0.62	(0.42–0.93)	0.85	(0.56–1.29)
All-sites-combined[d]	1	0.70	(0.69–0.72)	0.71	(0.63–0.79)	0.77	(0.69–0.86)	0.41	(0.36–0.46)	0.80	(0.71–0.89)	0.85	(0.76–0.95)	0.69	(0.61–0.78)	1.09	(0.96–1.23)	1.07	(0.93–1.22)
Female																			
Oral cavity and pharynx	1	0.76	(0.66–0.87)	0.89	(0.72–1.11)	0.77	(0.60–0.98)	0.54	(0.31–0.93)	0.69	(0.46–1.03)	0.41	(0.23–0.72)	0.56	(0.36–0.86)	2.05	(1.36–3.07)	0.91	(0.41–2.03)
Nasopharynx only	1	4.96	(3.58–6.86)	9.47	(6.51–13.80)	4.32	(2.62–7.12)	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]	[c]
Esophageal	1	0.40	(0.33–0.47)	0.40	(0.29–0.55)	0.20	(0.13–0.32)	0.90	(0.59–1.39)	[c]	[c]	[c]							

Table 5. Summary of key findings: cancer mortality patterns for AANHPI groups in relation to NHW. California, 2012–2017.

- NHOPIs have higher mortality for stomach, colorectal, liver, lung (males), breast, cervix, and endometrium cancer
- Southeast Asians have higher mortality for oral cavity and pharynx, nasopharynx (males), stomach, colorectal, liver, lung (males), and cervix cancer
- Vietnamese have higher mortality for nasopharynx (males), stomach, liver, and cervix cancer
- Koreans have higher mortality for stomach, colorectal (males), liver, and cervix cancer
- Chinese have higher mortality for nasopharynx, stomach, and liver cancer
- Filipinos have higher mortality for nasopharynx, liver, stomach (females), and cervix cancer
- Japanese have higher mortality for stomach and liver (females) cancer
- South Asians have a unique cancer mortality profile among AANHPIs, with the lowest mortality for all cancer sites combined, and significantly lower lung, colorectal, and pancreatic cancer mortality; for infection-related cancers (cervix-females, stomach, liver) which are typically high among AANHPIs, rates are significantly lower among South Asian males and equivalent between NHW and South Asian females

can be attributed to the excessive breast and endometrial cancer mortality in women, burdensome enough to counterbalance the lung and prostate cancer mortality among men. Excessive high lung cancer mortality for both males and females mirrored their reported high smoking prevalence (41). Previous research has shown that Native Hawaiians have a higher degree of susceptibility to lung cancer in comparison to Whites, Hispanics, and Japanese Americans, which cannot be accounted for by differences in sociodemographic and lifestyle-related risk factors (42). Similarly, in our study, Native Hawaiians were the NHOPI group with the highest proportion of deaths due to lung cancer (Supplementary Table S2). Moreover, colorectal and prostate cancer mortality was also remarkably high and NHOPI women were also burdened by high mortality for breast, cervical, and endometrial. Therefore, making the NHOPI population one of the most cancer-affected groups in the US. The preponderance of colorectal, breast, and endometrial cancers may be a direct result of the high prevalence of obesity (43–45), the highest among all racial/ethnic groups in the US with the exception of American Indian adults (46). Obesity is a known cancer risk factor for these cancers and is a determinant of poor cancer survival (45, 47). Together, these likely explain the high population-based mortality rates seen here (45, 47). Further, low uptake of routine cancer screenings, including Papanicolaou (Pap) tests for cervical cancer, mammograms for breast cancer, and colonoscopies for colorectal cancer, has been documented for the NHOPI group (48). Notably, in general health surveys, NHOPIs were also found to be more likely to report their overall health as fair or poor and to be bedridden because of illness or disability (49). As is the case with Southeast Asians, the excess in risk factors aforementioned for NHOPIs is influenced by their lower level of education, a higher rate of poverty, and greater uninsured population in comparison to Whites in the US (50). Given the substantial cancer mortality excess revealed among NHOPI in this study, the inclusion of their unique cancer experience as a disaggregated group from Asian Americans is an area of opportunity for cancer prevention.

Few studies discuss the cancer mortality burden among South Asians, comprised primarily of Indians and currently the second largest AANHPI group in the US, surpassing Filipinos and second only to Chinese (1). This apparent oversight is likely due to the fact that cancer does not appear to be a prominent concern for South Asians on a population basis, despite being highly afflicted by heart disease and diabetes (51, 52). Their low cancer mortality was evident across cancers common to all race/ethnicities (i.e., breast, lung, colorectal, and prostate) as well as those typically more common in other AANHPI groups: stomach and liver. For stomach cancer, the paradox observed among African populations in which low rates of stomach cancer are observed in the context of a high prevalence of *Helicobacter pylori* infection (53), may extend to South Asians. Combined with unusually low colorectal cancer mortality, these patterns also suggest that South Asian populations could be suitable for exploratory research into the impact of dietary practices, quite unique in this group, on cancers of the digestive tract. Liver cancer mortality rates were also low for South Asians, possibly attributable to lower HBV prevalence among this population in the US (28). Although the different causes of liver cancer have been extensively examined among Hispanic groups (54), they have not been studied by specific AANHPI populations. Moreover, low lung cancer mortality is consistent with historically lower smoking prevalence in South Asians in comparison to other AANHPI groups (55). Moreover, and in apparent contradiction with their lower mortality rates, South Asians have lower proportions of cancer screening than other AANHPI groups (56, 57), although there has been a significant increase in uptake of screening for some sites, such as colorectal cancer (58). Nonetheless, because the South Asian population in California may not reflect the full socioeconomic spectrum of South Asians across the US, other studies should be conducted to confirm these relatively favorable mortality findings in this population.

Since many AANHPIs are foreign-born, evaluating the impact of immigrant status and duration of stay on cancer patterns in the US is important (49). Japanese Americans, who had the highest US-born population proportion in our study, and Filipinos, who have historically been more fluent in English and demonstrate higher scores of acculturation than any other AANHPI group (59, 60) showed lower cancer mortality than NHWs and lower or similar mortality to other AANHPI groups for all-sites-combined. Further, Japanese men and women show the highest proportion of colorectal and breast cancer screening, respectively, within AANHPI subgroups (56, 57). Nonetheless, although length of stay information is not available in mortality data, our patterns suggest that acculturation does not adversely impact AANHPI cancer mortality as much as has been documented among Mexican Hispanics (61) or Afro-Caribbeans (62).

The main strength of this study is the ability to circumvent the problem of selection bias inherent in other epidemiologic study designs by using complete population-based data that includes every event of interest, in this case, every death. This is, to our knowledge, the most recent study comparing disaggregated cancer mortality patterns in a highly diverse group, the AANHPI. Data completeness, over 99% for race/ethnicity and birthplace variables for AANHPI cancer deaths in California allowed for accurate classification into specific groups. In addition, we took the opportunity to examine two groups that have been largely overlooked in previous mortality analyses: Southeast Asians and NHOPIs. The state of California, comprising almost 30% of the AANHPI population in the US, also includes an even larger proportion of older individuals more prone to death by cancer, compared with any other state in the country. Thus, California adequately represents this group in overall population size and age structure and can be considered ideal for studying cancer mortality patterns in AANHPI populations to identify any disparities.

As with any study, some limitations should be noted. There is a potential for misclassification of race/ethnicity; however, prior research comparing California death certificate birthplace information with self-reported interview data for AANHPI populations (including Filipino, Chinese, Japanese, Vietnamese, Southeast Asian) has found that death certificate birthplace data is complete and accurate and therefore research incorporating this data can be conducted reliably for these populations (63). The two groups of focus, Southeast Asians and NHOPIs, are themselves heterogeneous and often of combined races (multiracial). In aggregating these heterogeneous groups, which is necessary to highlight their overall plight, there may be a failure in capturing unique specificities among each subgroup, although these patterns may be difficult to assess due to small numbers. NHOPI, for example, are highly heterogeneous and include Native Hawaiians, Guamanians, Tongans, Samoans, and non-Hindu Fijians; they are also overwhelmingly multiracial (64). Some disparities in cancer incidence according to disaggregated NHOPI groups have been previously identified (35), and are consistent with our mortality findings. Most striking is the proportional preponderance of cancer deaths due to breast and endometrial cancers among Tongans, Samoans, and Fijians, which was not seen among Native Hawaiians or Guamanians (Supplementary Table S2). In addition, the Salmon Bias, in which those with deteriorated health may return to their home countries of origin to die (65), may cause an underestimation in mortality rates for AANHPI immigrants. Mortality as an outcome measure is a function of population-level, all-stages combined incidence and survival; the extent to which each factor into the patterns observed is unclear. For instance, the Southeast Asian group includes refugee immigrants (66) who may be less educated and more economically challenged than other AANHPI groups (67), which may translate into survival disadvantages that could impact their mortality rate on a population basis. In addition, there is possible misclassification arising from the methodology used to assign decedents reporting multiple races, but this was unlikely to bias our results since multiracial subjects only accounted for a small proportion of our sample. Further research among multiracial AANHPIs is needed. Finally, mortality data does not contain individual-level information on risk factors, comorbidities, screening, or treatment-related characteristics.

In conclusion, this study characterizes the distinct cancer mortality profiles among the heterogenous AANHPI population in California. Similarities were found for many of the groups, such as high mortality rates for stomach and liver cancers and relatively lower rates for breast and prostate. On the other hand, some important disparities between groups were noted, such as the high lung and colorectal cancer mortality among both Southeast Asians and NHOPIs. In particular, our study identified a disproportionate burden of breast and endometrial cancers among NHOPI women. Despite the fact that mortality for the most common cancers is decreasing, it is increasing for some sites (e.g., liver and endometrial; ref. 68) and the profiles have only partially been studied in these heterogenous groups. Overall, for the infrequently studied populations that we identified as facing the largest cancer burden, Southeast Asians and NHOPIs, additional focus is required to better understand the etiology of all cancers, in general, and identify areas of intervention, prevention, and control. This complex context highlights the need for a timely characterization of not only their mortality patterns but also incidence and survival.

Authors' Disclosures

No disclosures were reported.

Authors' Contributions

H.N. Medina: Conceptualization, formal analysis, writing–original draft, writing–review and editing. **K.E. Callahan:** Conceptualization, formal analysis, writing–original draft, writing–review and editing. **C.R. Morris:** Formal analysis, writing–review and editing. **C.A. Thompson:** Formal analysis, writing–review and editing. **A. Siweya:** Visualization, writing–review and editing. **P.S. Pinheiro:** Conceptualization, formal analysis, supervision, methodology, writing–original draft, writing–review and editing.

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