ORIGINAL RESEARCH

Geographic Variations in Cardiovascular Disease Mortality Among Asian American Subgroups, 2003–2011

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***Background*—**There are well-documented geographical differences in cardiovascular disease (CVD) mortality for non-Hispanic whites. However, it remains unknown whether similar geographical variation in CVD mortality exists for Asian American subgroups. This study aims to examine geographical differences in CVD mortality among Asian American subgroups living in the United States and whether they are consistent with geographical differences observed among non-Hispanic whites.

***Methods and Results*—**Using US death records from 2003 to 2011 (n=3 897 040 CVD deaths), age-adjusted CVD mortality rates per 100 000 population and age-adjusted mortality rate ratios were calculated for the 6 largest Asian American subgroups (Asian Indian, Chinese, Filipino, Japanese, Korean, and Vietnamese) and compared with non-Hispanic whites. There were consistently lower mortality rates for all Asian American subgroups compared with non-Hispanic whites across divisions for CVD mortality and ischemic heart disease mortality. However, cerebrovascular disease mortality demonstrated substantial geographical differences by Asian American subgroup. There were a number of regional divisions where certain Asian American subgroups (Filipino and Japanese men, Korean and Vietnamese men and women) possessed no mortality advantage compared with non-Hispanic whites. The most striking geographical variation was with Filipino men (age-adjusted mortality rate ratio=1.18; 95% CI, 1.14–1.24) and Japanese men (age-adjusted mortality rate ratio=1.05; 95% CI: 1.00–1.11) in the Pacific division who had significantly higher cerebrovascular mortality than non-Hispanic whites.

***Conclusions*—**There was substantial geographical variation in Asian American subgroup mortality for cerebrovascular disease when compared with non-Hispanic whites. It deserves increased attention to prioritize prevention and treatment in the Pacific division where approximately 80% of Filipinos CVD deaths and 90% of Japanese CVD deaths occur in the United States. **(*J Am Heart Assoc*. 2017;6:e005597. DOI: 10.1161/JAHA.117.005597.)**

Key Words: epidemiology • geographical disparities • mortality rate • race and ethnicity

Although mortality rates from cardiovascular disease (CVD) have decreased over the past decade in the United States, it continues to contribute to one fourth of all deaths.[1] Recent literature has shown that the burden of CVD in the United States differs geographically, with the southeast having particularly high mortality rates.[2] This pattern is consistent across sex and age strata and has been observed in both non-Hispanic white (NHW) and non-Hispanic black populations.[2] However, little is known about the US geographical disparities of CVD among Asian American subgroups. Asian Americans are one of the fastest growing racial/ethnic groups in the United States, increasing from a population of 11.9 to 18.2 million in the past decade.[3,4] Asian Americans have been traditionally known as the "model minority" and have been thought to have better health outcomes than other racial/ethnic minority groups and non-Hispanic whites.[5] However, recent studies have suggested that certain Asian American subgroups, such as Japanese, Filipinos, and Asian Indians, have elevated risks for CVD-specific mortality and morbidity.[6,7] It remains unclear whether the geographical patterns identified in non-Hispanic whites and blacks exist among Asian Americans.

In addition, further study is needed to better understand geographical variations within Asian American subgroups. Asian Americans are a diverse population with different immigration histories, lifestyle and dietary patterns, and cultures—all of which could contribute to regional differences

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Clinical Perspective

What Is New?

- Whereas lower mortality rates were observed among Asian American subgroups compared with non-Hispanic whites across divisions for cardiovascular disease mortality and ischemic heart disease mortality, there were a number of regional divisions where certain Asian American possessed no mortality advantage in cerebrovascular disease mortality.

What Are the Clinical Implications?

- Etiological research to better understand geographically related causes of cardiovascular disease and how these contributing factors may differentially impact cerebrovascular disease across Asian American subgroups may help clinicians incorporate culturally competent approaches and provide better care to Asian American patients.

in CVD mortality for Asian American subgroups because of differential migration patterns to parts of the United States, and also potentially because of the effects of those areas on CVD mortality. In terms of the first group of processes that pertain to selection, migration to different parts of the United States may have happened at different times for different Asian American subgroups, and these population differences may be associated with better or worse health. In addition, individuals from a particular country may also have differentially located themselves in the United States by attributes that may be intricately linked to health, such as socioeconomic position. Other factors associated with differential migration may also play a role in observed geographical differences in health. Examples include differences in migration associated with different levels of ties with the country of origin, different types of economic activity in the new environment, or different infrastructure of the place of settlement that was differentially beneficial for migrating individuals.[8] Alternatively, the second broad explanation is that the impact of the physical and social environment by region may have differential effects on Asian American subgroups as compared with non-Hispanic whites. This may be true, for example, because ethnic enclaves may insulate individuals of Asian American subgroups from deleterious or beneficial social environments.

Our goal with this study is to better understand geographical variation of CVD mortality among the 6 largest Asian American subgroups by the 9 US Census divisions. Our results will provide a basis for developing testable hypotheses for understanding the impacts of regional US environments and migration patterns on CVD mortality among Asian American subgroups. Our findings also may have important clinical implications for identifying Asian American subgroups in different regions of the country that may be at a relatively increased risk of CVD.

Methods

The institutional review board of Stanford University (Stanford, CA) approved this study and provided a waiver for use of these publicly available mortality and US Census data. CVD mortality among the 6 largest Asian American subgroups and non-Hispanic whites were examined using the Multiple Cause of Death mortality database from the National Center for Health Statistics, 2003–2011. It contains underlying cause of death (International Classification of Diseases, Tenth Revision codes), race/ethnicity, sex, age of death, and places of birth, death, and residence as well as other decedent

Table 1. Cardiovascular Deaths by Census Division, 2003–2011

	Non-Hispanic White	Asian Indian	Chinese	Filipino	Japanese	Korean	Vietnamese
New.England	136 815	114	130	79	30	43	46
Mid.Atlantic	597 825	4143	6999	1780	306	1648	221
E.N.Central	807 585	1655	1046	1151	521	640	249
W.N.Central	359 311	212	198	197	133	102	251
Sth.Atlantic	581 031	1127	806	1205	296	316	383
E.S.Central	23 329	7	3	7	5	5	5
W.S.Central	445 711	1184	812	653	291	402	1243
Mountain	130 347	104	259	556	440	105	105
Pacific	711 360	3514	18 328	21 737	17 792	5432	4710
Total	3 793 314	12 060	28 581	27 365	19 814	8693	7213

This only includes deaths for states and years reporting deaths in all 6 primary Asian American groups. For the analysis in the East South Central Division that includes all years but only non-Hispanic white, Chinese, Filipino, and Japanese, the total numbers of cardiovascular deaths are: 428 829 for non-Hispanic white, 133 for Chinese, 126 for Filipino, and 66 for Japanese.

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Table 2. CVD AMR Per 100 000 Population by Sex and Race/Ethnicity, 2003–2011

	NHW		Asian Indian		Chinese		Filipino		Japanese		Korean		Vietnamese	
	AMR	95% CI	AMR	95% CI	AMR	95% CI	AMR	95% CI	AMR	95% CI	AMR	95% CI	AMR	95% CI
Male														
New.England	403	400 to 406	146	108 to 195	154	117 to 199	208	146 to 289	99	34 to 229	141	74 to 246	165	98 to 263
Mid.Atlantic	487	485 to 489	301	287 to 315	244	236 to 252	268	248 to 289	152	121 to 189	235	217 to 255	184	149 to 225
E.N.Central	463	462 to 465	240	222 to 259	172	157 to 188	227	207 to 249	244	213 to 280	190	166 to 218	185	150 to 227
W.N.Central	428	426 to 430	179	143 to 222	129	102 to 161	271	215 to 337	188	131 to 261	164	105 to 246	167	136 to 203
Sth.Atlantic	421	419 to 422	214	196 to 233	182	164 to 201	258	236 to 281	146	109 to 194	79	66 to 95	102	87 to 119
W.S.Central	488	486 to 491	257	235 to 282	179	162 to 197	264	233 to 298	265	201 to 344	199	161 to 242	203	186 to 221
Mountain	390	387 to 393	222	165 to 293	210	176 to 249	277	243 to 314	335	290 to 386	264	189 to 360	188	136 to 254
Pacific	459	457 to 460	276	263 to 289	243	238 to 248	382	375 to 390	350	343 to 358	230	220 to 240	206	197 to 214
Female														
New.England	314	312 to 316	109	77 to 150	150	116 to 193	130	88 to 186	107	69 to 163	205	132 to 306	132	77 to 214
Mid.Atlantic	386	385 to 388	234	222 to 246	203	196 to 210	182	170 to 195	149	129 to 170	225	210 to 240	133	105 to 167
E.N.Central	358	357 to 359	221	204 to 239	169	154 to 184	160	146 to 174	151	134 to 169	211	190 to 234	170	138 to 208
W.N.Central	334	333 to 336	197	157 to 244	150	122 to 182	166	133 to 206	144	117 to 178	170	128 to 221	151	122 to 184
Sth.Atlantic	312	310 to 313	157	142 to 174	148	133 to 164	173	159 to 188	127	112 to 145	73	62 to 86	92	77 to 108
W.S.Central	385	383 to 386	238	216 to 262	143	129 to 159	161	143 to 181	169	147 to 194	222	194 to 254	188	172 to 205
Mountain	305	301 to 307	180	125 to 252	158	129 to 191	165	144 to 189	183	159 to 210	155	114 to 207	156	111 to 214
Pacific	359	358 to 360	214	202 to 226	196	192 to 200	233	228 to 237	208	203 to 212	213	205 to 221	182	175 to 190

AMR indicates age-adjusted mortality rates; CVD, cardiovascular disease; NHW, non-Hispanic white.

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Table 3. Ischemic Heart Disease AMR Per 100 000 Population by Sex and Race/Ethnicity, 2003–2011

	Ischemic Heart Disease													
	NHW		Asian Indian		Chinese		Filipino		Japanese		Korean		Vietnamese	
	AMR	95% CI	AMR	95% CI	AMR	95% CI	AMR	95% CI	AMR	95% CI	AMR	95% CI	AMR	95% CI
Male														
New.England	221	219 to 224	95	65 to 137	72	48 to 106	123	77 to 190	44	8 to 148	63	21 to 146	70	30 to 142
Mid.Atlantic	317	315 to 318	215	204 to 227	164	158 to 171	167	151 to 184	88	64 to 117	155	140 to 171	97	72 to 129
E.N.Central	262	261 to 263	139	126 to 154	81	70 to 92	114	100 to 130	138	114 to 165	96	79 to 117	75	54 to 103
W.N.Central	232	230 to 233	96	71 to 129	56	39 to 78	141	103 to 191	110	68 to 169	93	51 to 159	62	44 to 85
Sth.Atlantic	235	234 to 236	112	100 to 126	78	67 to 91	137	121 to 154	78	52 to 114	36	27 to 47	45	35 to 57
W.S.Central	278	277 to 280	151	134 to 170	74	63 to 86	130	109 to 154	143	98 to 203	89	66 to 118	85	75 to 97
Mountain	206	204 to 208	131	90 to 188	96	73 to 123	113	92 to 138	161	131 to 197	110	65 to 178	60	33 to 102
Pacific	264	263 to 265	180	170 to 191	123	120 to 127	201	196 to 206	178	173 to 183	122	115 to 129	104	98 to 110
Female														
New.England	141	139 to 142	54	32 to 84	52	33 to 80	51	26 to 92	35	15 to 73	73	32 to 144	60	25 to 122
Mid.Atlantic	228	227 to 230	150	140 to 160	126	121 to 132	101	92 to 111	79	65 to 95	138	126 to 150	69	49 to 95
E.N.Central	161	160 to 162	99	88 to 112	69	60 to 79	68	60 to 78	65	54 to 78	99	85 to 116	87	64 to 116
W.N.Central	138	137 to 139	77	53 to 109	29	18 to 45	38	23 to 60	61	43 to 85	64	39 to 98	37	24 to 56
Sth.Atlantic	140	139 to 141	70	60 to 82	60	51 to 71	69	60 to 79	57	46 to 70	25	18 to 33	31	23 to 42
W.S.Central	174	173 to 175	114	99 to 131	47	39 to 56	60	49 to 73	72	58 to 89	108	88 to 131	63	53 to 73
Mountain	115	114 to 117	105	63 to 164	41	27 to 59	55	43 to 70	57	44 to 74	36	19 to 64	68	39 to 111
Pacific	168	167 to 169	114	106 to 123	82	79 to 85	105	102 to 109	82	80 to 85	99	94 to 104	83	78 to 88

AMR indicates age-adjusted mortality rates; NHW, non-Hispanic white.

Table 4. Cerebrovascular Disease AMR Per 100 000 Population by Sex and Race/Ethnicity, 2003–2011

	Cerebrovascular Disease													
	NHW		Asian Indian		Chinese		Filipino		Japanese		Korean		Vietnamese	
	AMR	95% CI	AMR	95% CI	AMR	95% CI	AMR	95% CI	AMR	95% CI	AMR	95% CI	AMR	95% CI
Male														
New.England	52	51 to 53	18	7 to 41	32	17 to 56	50	22 to 100	43	5 to 155	25	4 to 88	42	12 to 109
Mid.Atlantic	49	48 to 50	35	31 to 40	30	28 to 33	41	33 to 49	29	17 to 48	34	28 to 42	46	30 to 70
E.N.Central	64	63 to 65	43	35 to 51	44	37 to 53	52	42 to 63	41	29 to 57	46	34 to 60	46	29 to 69
W.N.Central	65	64 to 66	27	14 to 46	35	22 to 53	57	33 to 93	25	8 to 60	22	6 to 63	53	36 to 75
Sth.Atlantic	56	55 to 57	38	31 to 47	46	37 to 56	47	38 to 57	15	5 to 37	22	15 to 30	29	21 to 39
W.S.Central	69	68 to 70	43	33 to 54	57	48 to 68	61	47 to 79	56	29 to 99	54	36 to 80	64	55 to 75
Mountain	54	53 to 56	47	22 to 90	45	30 to 64	51	38 to 69	69	49 to 95	43	17 to 93	43	21 to 79
Pacific	66	65 to 67	44	39 to 50	59	57 to 62	78	75 to 81	70	66 to 73	53	48 to 58	57	52 to 62
Female														
New.England	58	57 to 59	17	6 to 38	50	31 to 76	37	17 to 73	17	5 to 50	51	20 to 111	28	7 to 76
Mid.Atlantic	51	50 to 52	32	28 to 37	34	31 to 37	35	30 to 41	29	21 to 39	39	33 to 46	34	21 to 53
E.N.Central	70	69 to 71	53	45 to 62	49	41 to 57	44	37 to 51	45	36 to 56	61	50 to 74	51	34 to 73
W.N.Central	72	71 to 73	49	31 to 75	64	47 to 86	78	56 to 105	45	30 to 66	66	41 to 101	60	43 to 82
Sth.Atlantic	61	60 to 62	32	25 to 40	37	30 to 46	50	43 to 59	36	28 to 47	25	19 to 33	28	21 to 37
W.S.Central	80	79 to 81	56	46 to 69	40	32 to 48	49	40 to 61	46	35 to 60	59	45 to 76	59	51 to 69
Mountain	65	63 to 66	24	8 to 58	40	27 to 59	50	39 to 64	49	38 to 66	55	32 to 90	49	26 to 86
Pacific	73	72 to 74	47	42 to 53	55	53 to 57	59	57 to 62	55	53 to 58	55	51 to 59	58	54 to 62

AMR indicates age-adjusted mortality rates; NHW, non-Hispanic white.

characteristics. Race and ethnicity are reported by the funeral director who collected the information from an informant or on the basis of observation. Before 2003, the US Standard Certificate of Death listed only 3 specific Asian American subgroups (Chinese, Filipino, and Japanese), but the 2003 revision added Asian Indian, Korean, and Vietnamese. Adoption of the 2003 standard has varied by states; our study includes only states and years that reported on all 6 groups. Given that state-specific mortality rates can be unstable because of small numbers within Asian American subgroups, Census division (9 groups of states: New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain, and Pacific)[9] was used as the geographical unit for analysis in order to reach reliable estimates of mortality rates in each Asian American subgroup.[10] Reported state of residence of the decedent was used to assign the death to a Census division.[9]

Ascertainment of CVD Mortality

CVD mortality was captured using the underlying cause listed on the death certificate. Deaths were attributed to CVD if the following International Classification of Diseases, Tenth Revision codes were listed as the primary cause of death: (I00–I09, I10, I11, I12, I13, I15, I20–I51.9, I60–I69, I70, and I71–I78). Ischemic heart disease (International Classification of Diseases, Tenth Revision, I20–I25) and cerebrovascular disease (International Classification of Diseases, Tenth Revision, I60–I69) were also examined to test variation in mortality patterns by CVD cause subtype. The East South Central division was excluded from primary analyses because of unstable estimation in Asian American subgroups. Sparse data in this division are primarily because of the lack of adoption of the 2003 standard by the states in this division as well as small Asian American populations.

Mortality Measures

For the 6 Asian American subgroups and non-Hispanic whites, sex-specific age-adjusted mortality rates (AMRs) of CVD and CVD subtypes per 100 000 population were calculated in each Census division. Denominator data for Asian American subgroup as well as sex- and age-specific population counts by Census division were extracted from the 2000 and 2010 US Census. All statistical and graphical analyses were

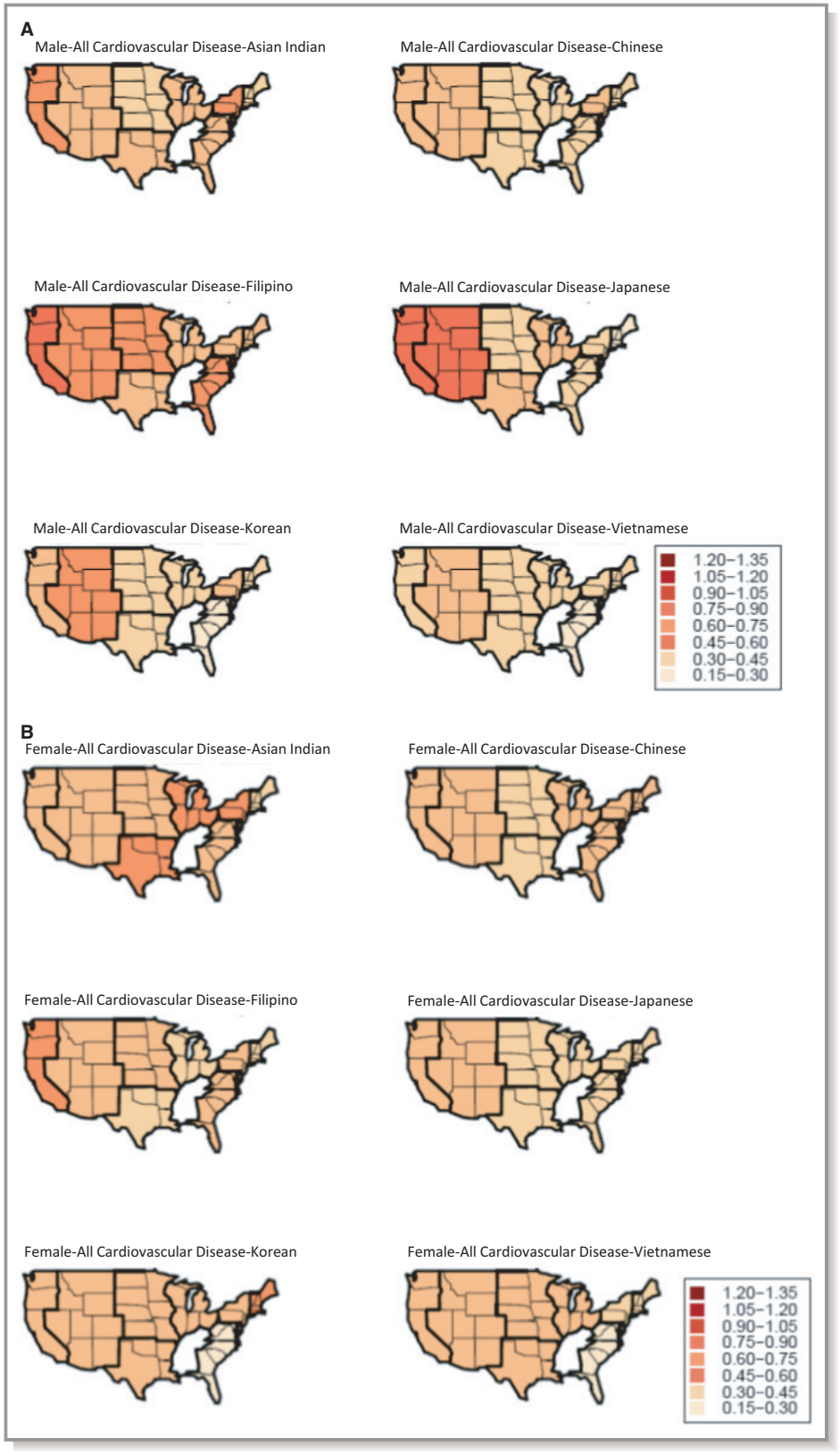

Figure 1. A, Age-adjusted CVD mortality rate ratios/AMRR for Asian subgroups using non-Hispanic whites as a reference group, males, 2003–2011. B, Age-adjusted CVD mortality rate ratios/AMRR for Asian subgroups using non-Hispanic whites as reference group, females, 2003–2011. AMRR indicates age-adjusted CVD mortality rate ratios; CVD, cardiovascular disease.

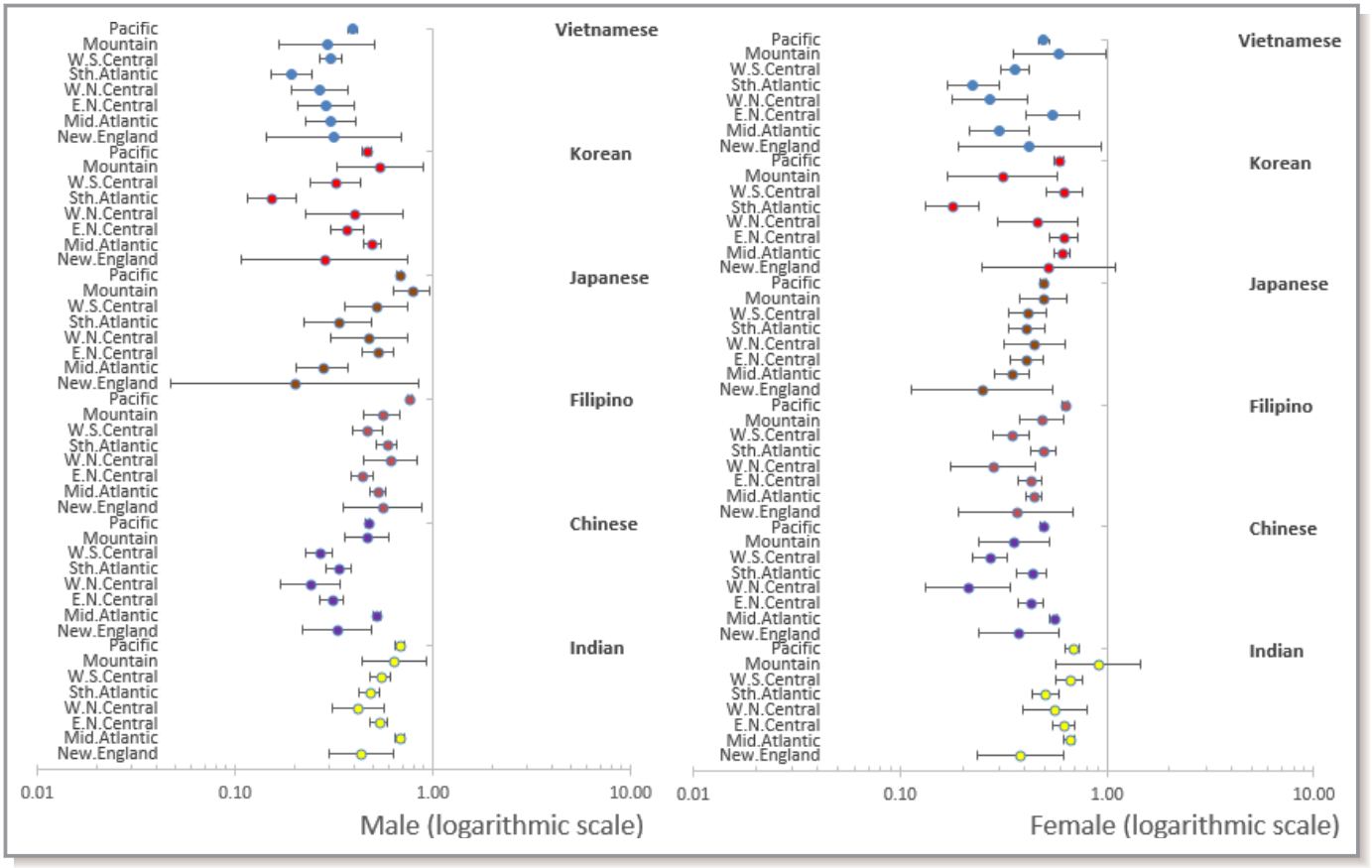

Figure 2. Age-adjusted ischemic mortality rate ratios/AMRR for Asian subgroups using non-Hispanic whites as a reference group, by sex. Sth.Atlantic indicates South Atlantic; W.N.Central, West North Central States; W.S.Central, West South Central. AMRR indicates age-adjusted CVD mortality rate ratios.

performed in R software (version 3.1.1; R Foundation for Statistical Computing, Vienna, Austria).[11] Age-adjusted mortality rates were estimated using the epitools package for R[12] and reported through direct standardization to the US standard population in year 2000 using the following age categories: 25 to 34, 35 to 44, 45 to 59, 60 to 74, and 75+.

In addition to age-adjusted mortality rates, sex-specific age-adjusted CVD mortality rate ratios (AMRRs) were calculated to compare the adjusted rates in each Asian American subgroup with non-Hispanic whites in the same Census division. An AMRR larger than 1 indicates that the specific race/ethnic-sex group has higher CVD or CVD subtype mortality rates than non-Hispanic whites in that division.

Maps

CVD age-adjusted mortality rate ratio was mapped using the maps package for R[13] to visualize quantitative differences among the 6 Asian American subgroups compared with non-Hispanic whites and across the 9 Census divisions. Eight-level color ramps were used to divide the division-specific AMRR based on the mortality rate ratio distribution.

Results

A total of 3 897 040 death records with CVD as the primary cause of death were included in this study (Table 1).

Age-Adjusted CVD Mortality Rate

Age-adjusted CVD mortality rates and 95% CIs, by sex and racial/ethnic group, are presented in Table 2 and by CVD subtype (ischemic heart disease and cerebrovascular disease) in Tables 3 and 4. For Asian Indians, Japanese, Koreans, and Vietnamese, there were nearly 2-fold higher total CVD mortality rates when comparing the highest versus lowest divisions. For Asian American subgroups, age-adjusted CVD mortality rates by sex were highest in Filipino men in the Pacific division (382; 95% CI, 375–390 per 100 000) and Indian women in the West South Central division (238; 95% CI, 216–262 per 100 000 population), and lowest in Korean men (79; 95% CI, 66–95 per 100 000 population) and women (73; 95% CI, 62–86 per 100 000 population) in the South Atlantic division.

As relative comparisons, there was greater variability across division for ischemic heart disease and cerebrovascular disease,

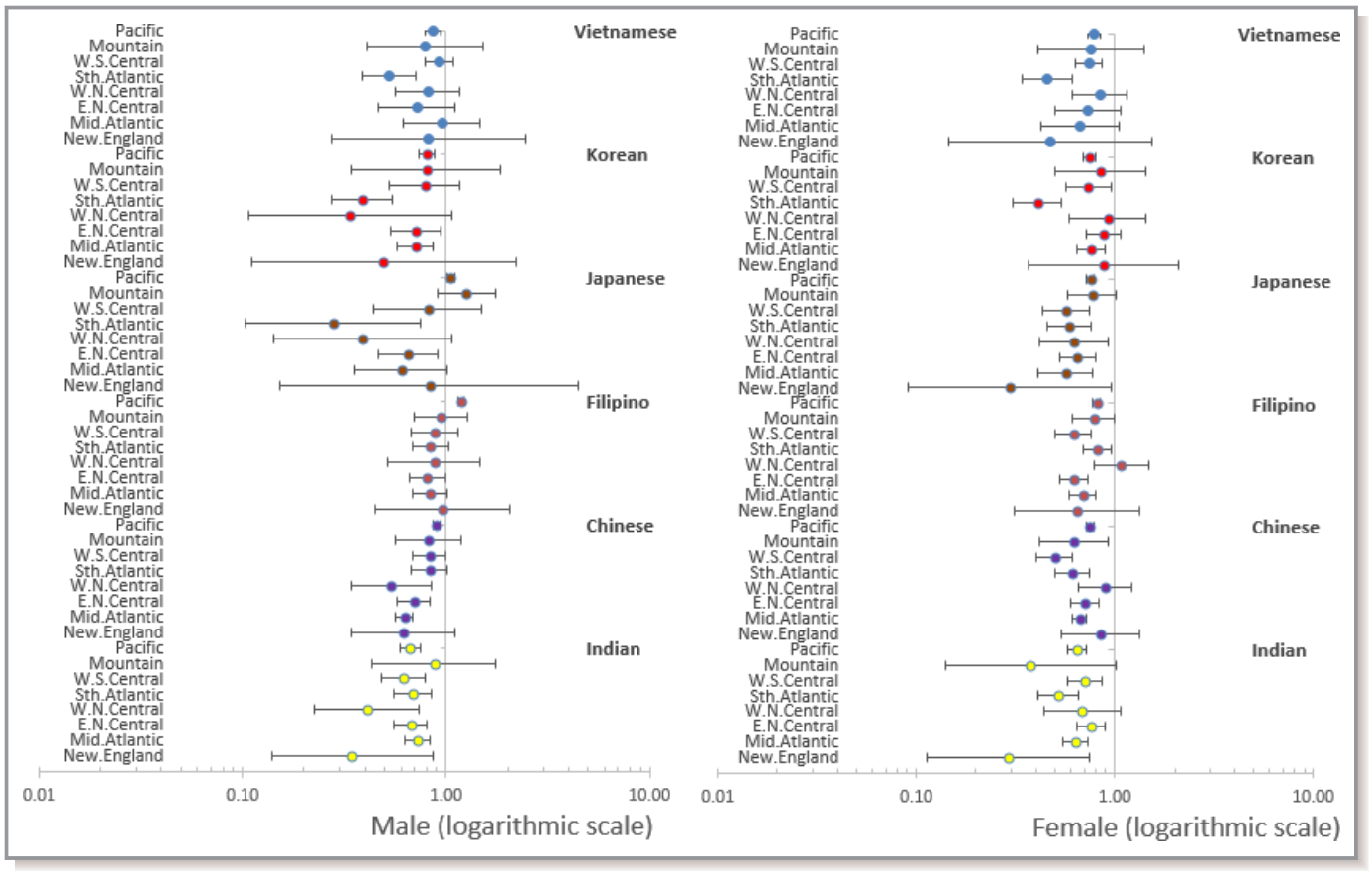

Figure 3. Age-adjusted cerebrovascular disease mortality rate ratios/AMRR for Asian subgroups using non-Hispanic whites as a reference group, by sex. Sth.Atlantic indicates South Atlantic; W.N.Central, West North Central States; W.S.Central, West South Central. AMRR indicates age-adjusted CVD mortality rate ratios.

with close to double or greater differences in mortality rates by division within all Asian American subgroups. For ischemic heart disease, the highest AMRs were observed in Asian Indian men (215; 95% CI, 204–227 per 100 000 population) and women (150; 95% CI, 140–160 per 100 000 population) in the Mid-Atlantic division and lowest in Korean men (36; 95% CI, 27–47 per 100 000 population) and women in the South Atlantic (25; 95% CI, 18–33 per 100 000 population). For cerebrovascular disease, Filipino men in Pacific (78; 95% CI, 75–81 per 100 000) and Filipino women in the Western North Central division (78; 95% CI, 56–105 per 100 000) had the highest AMRs whereas Japanese men in the South Atlantic (15; 95% CI, 5–37 per 100 000 population) and Japanese women (17; 95% CI, 5–50 per 100 000 population) and Asian Indian women (17; 95% CI, 6–38 per 100 000 population) in New England had the lowest AMRs across the 6 Asian American subgroups.

Age-Adjusted CVD Mortality Rate Ratio

AMRRs were calculated to better compare the age-adjusted CVD mortality rates in Asian American subgroups with non-Hispanic whites as the reference group in each Census division. The reason for this focus of our analysis and presentation of data is to determine whether the geographical variation among Asian American subgroups differed from those of non-Hispanic whites. We present the AMRs in 2 ways: first, in the map in Figure 1 and forest plot in Figures 2 and 3 and, second, in Tables 5 through 7 that include estimated 95% CIs that allow an assessment of the stability of the mortality ratios. Asian American subgroups had lower age-standardized mortality rates for total CVD (Figure 1 and Table 5) and specifically for ischemic heart disease (Figure 2 and Table 6) in both men and women than their non-Hispanic white counterparts in the same division (AMRR<1). For almost all divisions and groups, the 95% CIs did not include one, consistent with the hypothesis that rates of CVD and ischemic heart disease across all divisions are lower for all 6 Asian American subgroups (Tables 5 and 6). The only exceptions to this were for ischemic disease mortality for Asian Indian women in the Mountain division (0.91; 95% CI, 0.56–1.46) and for Korean women living in New England (0.52; 95% CI, 0.25–1.10).

The most heterogeneity was observed for cerebrovascular disease (Figure 3 and Table 7). For Filipino men there was 1

Table 5. Age-Adjusted CVD Mortality Rate Ratios (AMRR) for Asian Subgroups Using NHW as a Reference Group With 95% CI, 2003–2011

	Asian Indian		Chinese		Filipino		Japanese		Korean		Vietnamese	
	AMRR	95% CI	AMRR	95% CI	AMRR	95% CI	AMRR	95% CI	AMRR	95% CI	AMRR	95% CI
Male												
New.England	0.36	0.27 to 0.49	0.38	0.29 to 0.50	0.52	0.37 to 0.73	0.25	0.09 to 0.63	0.35	0.19 to 0.64	0.41	0.25 to 0.67
Mid.Atlantic	0.62	0.59 to 0.65	0.50	0.48 to 0.52	0.55	0.51 to 0.59	0.31	0.25 to 0.39	0.48	0.45 to 0.52	0.38	0.31 to 0.46
E.N.Central	0.52	0.48 to 0.56	0.37	0.34 to 0.41	0.49	0.45 to 0.54	0.53	0.46 to 0.60	0.41	0.36 to 0.47	0.40	0.32 to 0.49
W.N.Central	0.42	0.34 to 0.52	0.30	0.24 to 0.38	0.63	0.51 to 0.79	0.44	0.31 to 0.62	0.38	0.25 to 0.59	0.39	0.32 to 0.48
Sth.Atlantic	0.51	0.47 to 0.55	0.43	0.39 to 0.48	0.61	0.56 to 0.67	0.35	0.26 to 0.46	0.19	0.16 to 0.23	0.24	0.21 to 0.28
W.S.Central	0.53	0.48 to 0.58	0.37	0.33 to 0.40	0.54	0.48 to 0.61	0.54	0.42 to 0.71	0.41	0.33 to 0.50	0.42	0.38 to 0.45
Mountain	0.57	0.43 to 0.76	0.54	0.45 to 0.64	0.71	0.62 to 0.80	0.86	0.74 to 0.99	0.68	0.49 to 0.93	0.48	0.35 to 0.66
Pacific	0.60	0.57 to 0.63	0.53	0.52 to 0.54	0.83	0.82 to 0.85	0.76	0.75 to 0.78	0.50	0.48 to 0.52	0.45	0.43 to 0.47
Female												
New.England	0.35	0.25 to 0.49	0.48	0.37 to 0.62	0.41	0.28 to 0.60	0.34	0.22 to 0.53	0.65	0.43 to 1.00	0.42	0.25 to 0.70
Mid.Atlantic	0.60	0.57 to 0.64	0.52	0.51 to 0.54	0.47	0.44 to 0.51	0.39	0.34 to 0.44	0.58	0.54 to 0.62	0.35	0.27 to 0.43
E.N.Central	0.62	0.57 to 0.67	0.47	0.43 to 0.51	0.45	0.41 to 0.49	0.42	0.37 to 0.47	0.59	0.53 to 0.66	0.48	0.39 to 0.58
W.N.Central	0.59	0.47 to 0.74	0.45	0.37 to 0.55	0.50	0.40 to 0.62	0.43	0.35 to 0.53	0.51	0.39 to 0.67	0.45	0.37 to 0.55
Sth.Atlantic	0.51	0.46 to 0.56	0.48	0.43 to 0.53	0.56	0.51 to 0.60	0.41	0.36 to 0.47	0.23	0.20 to 0.28	0.29	0.25 to 0.35
W.S.Central	0.62	0.56 to 0.68	0.37	0.33 to 0.41	0.42	0.37 to 0.47	0.44	0.38 to 0.50	0.58	0.50 to 0.66	0.49	0.45 to 0.53
Mountain	0.59	0.42 to 0.84	0.52	0.43 to 0.63	0.54	0.47 to 0.62	0.60	0.52 to 0.69	0.51	0.38 to 0.69	0.51	0.37 to 0.71
Pacific	0.60	0.56 to 0.63	0.55	0.54 to 0.56	0.65	0.64 to 0.66	0.58	0.57 to 0.59	0.59	0.57 to 0.61	0.51	0.49 to 0.53

CVD indicates cardiovascular disease; NHW, non-Hispanic whites.

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Table 6. Age-Adjusted Ischemic Heart Disease Mortality Rate Ratios (AMRR) for Asian Subgroups Using NHW as a Reference Group With 95% CI, 2003–2011

	Asian Indian		Chinese		Filipino		Japanese		Korean		Vietnamese	
	AMRR	95% CI	AMRR	95% CI	AMRR	95% CI	AMRR	95% CI	AMRR	95% CI	AMRR	95% CI
Male												
New.England	0.43	0.30 to 0.63	0.33	0.22 to 0.49	0.56	0.35 to 0.88	0.20	0.05 to 0.85	0.28	0.11 to 0.75	0.31	0.14 to 0.69
Mid.Atlantic	0.68	0.64 to 0.72	0.52	0.50 to 0.54	0.53	0.48 to 0.58	0.28	0.20 to 0.37	0.49	0.44 to 0.54	0.31	0.23 to 0.41
E.N.Central	0.53	0.48 to 0.59	0.31	0.27 to 0.35	0.44	0.38 to 0.50	0.53	0.44 to 0.63	0.37	0.30 to 0.45	0.29	0.21 to 0.40
W.N.Central	0.42	0.31 to 0.56	0.24	0.17 to 0.34	0.61	0.45 to 0.83	0.48	0.30 to 0.75	0.40	0.23 to 0.71	0.27	0.19 to 0.37
Sth.Atlantic	0.48	0.42 to 0.54	0.33	0.29 to 0.39	0.58	0.52 to 0.66	0.33	0.22 to 0.49	0.15	0.12 to 0.20	0.19	0.15 to 0.24
W.S.Central	0.54	0.48 to 0.61	0.27	0.23 to 0.31	0.47	0.39 to 0.56	0.51	0.36 to 0.74	0.32	0.24 to 0.43	0.31	0.27 to 0.35
Mountain	0.64	0.44 to 0.92	0.46	0.36 to 0.60	0.55	0.45 to 0.67	0.78	0.63 to 0.96	0.54	0.32 to 0.89	0.29	0.17 to 0.51
Pacific	0.68	0.64 to 0.72	0.47	0.45 to 0.48	0.76	0.74 to 0.78	0.67	0.65 to 0.69	0.46	0.44 to 0.49	0.39	0.37 to 0.42
Female												
New.England	0.38	0.24 to 0.61	0.37	0.24 to 0.58	0.36	0.19 to 0.69	0.25	0.11 to 0.55	0.52	0.25 to 1.10	0.42	0.19 to 0.93
Mid.Atlantic	0.66	0.61 to 0.70	0.55	0.53 to 0.58	0.44	0.40 to 0.49	0.34	0.28 to 0.42	0.60	0.55 to 0.66	0.30	0.22 to 0.42
E.N.Central	0.62	0.55 to 0.70	0.43	0.37 to 0.49	0.43	0.37 to 0.49	0.41	0.34 to 0.49	0.62	0.53 to 0.72	0.54	0.40 to 0.73
W.N.Central	0.56	0.39 to 0.80	0.21	0.13 to 0.34	0.28	0.17 to 0.45	0.44	0.32 to 0.62	0.46	0.29 to 0.73	0.27	0.18 to 0.42
Sth.Atlantic	0.50	0.43 to 0.59	0.43	0.37 to 0.51	0.49	0.43 to 0.56	0.41	0.33 to 0.50	0.18	0.13 to 0.24	0.22	0.17 to 0.30
W.S.Central	0.66	0.57 to 0.75	0.27	0.22 to 0.33	0.34	0.28 to 0.42	0.41	0.33 to 0.51	0.62	0.51 to 0.76	0.36	0.31 to 0.42
Mountain	0.91	0.56 to 1.46	0.35	0.24 to 0.52	0.48	0.38 to 0.61	0.49	0.38 to 0.63	0.31	0.17 to 0.57	0.59	0.35 to 0.99
Pacific	0.68	0.63 to 0.73	0.49	0.47 to 0.50	0.63	0.61 to 0.65	0.49	0.47 to 0.51	0.59	0.56 to 0.62	0.49	0.46 to 0.53

NHW indicates non-Hispanic whites.

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Table 7. Age-Adjusted Cerebrovascular Disease Mortality Rate Ratios (AMRR) for Asian Subgroups Using NHW as a Reference Group With 95% CI, 2003–2011

	Asian Indian		Chinese		Filipino		Japanese		Korean		Vietnamese	
	AMRR	95% CI	AMRR	95% CI	AMRR	95% CI	AMRR	95% CI	AMRR	95% CI	AMRR	95% CI
Male												
New.England	0.34	0.14 to 0.86	0.62	0.34 to 1.11	0.96	0.45 to 2.06	0.82	0.15 to 4.50	0.49	0.11 to 2.19	0.82	0.27 to 2.46
Mid.Atlantic	0.72	0.63 to 0.83	0.62	0.57 to 0.69	0.83	0.69 to 1.01	0.60	0.36 to 1.01	0.70	0.57 to 0.86	0.95	0.62 to 1.47
E.N.Central	0.67	0.55 to 0.81	0.69	0.58 to 0.83	0.81	0.66 to 0.99	0.65	0.46 to 0.91	0.71	0.54 to 0.95	0.72	0.47 to 1.11
W.N.Central	0.41	0.23 to 0.74	0.54	0.34 to 0.84	0.88	0.52 to 1.47	0.39	0.14 to 1.06	0.34	0.11 to 1.07	0.81	0.57 to 1.17
Sth.Atlantic	0.68	0.55 to 0.85	0.83	0.67 to 1.01	0.84	0.68 to 1.03	0.28	0.10 to 0.75	0.39	0.27 to 0.55	0.52	0.39 to 0.71
W.S.Central	0.61	0.48 to 0.78	0.83	0.69 to 0.99	0.88	0.68 to 1.15	0.81	0.44 to 1.50	0.78	0.52 to 1.17	0.93	0.79 to 1.08
Mountain	0.87	0.43 to 1.75	0.82	0.57 to 1.19	0.94	0.70 to 1.28	1.26	0.91 to 1.75	0.8	0.34 to 1.85	0.78	0.41 to 1.51
Pacific	0.67	0.59 to 0.75	0.89	0.86 to 0.93	1.18	1.14 to 1.24	1.05	1.00 to 1.11	0.8	0.73 to 0.87	0.86	0.79 to 0.93
Female												
New.England	0.29	0.11 to 0.74	0.85	0.54 to 1.34	0.64	0.31 to 1.33	0.30	0.09 to 0.96	0.88	0.37 to 2.08	0.47	0.15 to 1.53
Mid.Atlantic	0.63	0.55 to 0.73	0.67	0.61 to 0.72	0.69	0.59 to 0.80	0.57	0.41 to 0.78	0.76	0.65 to 0.89	0.67	0.43 to 1.05
E.N.Central	0.76	0.64 to 0.89	0.70	0.60 to 0.83	0.63	0.53 to 0.74	0.65	0.52 to 0.81	0.88	0.72 to 1.06	0.73	0.50 to 1.06
W.N.Central	0.68	0.44 to 1.07	0.89	0.66 to 1.21	1.08	0.78 to 1.48	0.62	0.42 to 0.92	0.92	0.59 to 1.44	0.84	0.61 to 1.15
Sth.Atlantic	0.52	0.41 to 0.65	0.61	0.50 to 0.75	0.82	0.70 to 0.96	0.59	0.45 to 0.76	0.41	0.31 to 0.54	0.46	0.34 to 0.61
W.S.Central	0.70	0.57 to 0.86	0.50	0.40 to 0.61	0.62	0.50 to 0.76	0.57	0.43 to 0.75	0.74	0.56 to 0.96	0.74	0.63 to 0.86
Mountain	0.38	0.14 to 1.01	0.62	0.42 to 0.93	0.78	0.61 to 0.99	0.77	0.58 to 1.01	0.85	0.50 to 1.44	0.76	0.41 to 1.40
Pacific	0.64	0.57 to 0.72	0.75	0.72 to 0.78	0.81	0.78 to 0.84	0.75	0.72 to 0.79	0.75	0.70 to 0.80	0.79	0.73 to 0.85

NHW indicates non-Hispanic whites.

division with lower mortality of cerebrovascular disease, for Japanese men there were 2 divisions with lower mortality, for Korean men and women there were 4 divisions with lower mortality each, and for Vietnamese men and women there were 2 and 3 divisions with lower mortality, respectively. Higher cerebrovascular disease mortality rates relative to non-Hispanic whites were observed in Filipino men (AMRR=1.18; 95% CI, 1.14–1.24) and Japanese men (AMRR=1.05; 95% CI, 1.00–1.11) in the Pacific division.

CVD Cause Subtype Analysis of the East South Central Division

There was insufficient data on all 6 Asian American subgroups in the East South Central division attributed to late adoption of the 2003 standard in states in this division. For this subgroup analysis of the East South Central division, part of the well-known "stroke belt," we used data on subgroups with categories present before the 2003 revision of the US death certificate (Chinese, Filipino, Japanese, and non-Hispanic white decedents). Consistent with the literature, non-Hispanic whites had particularly high CVD mortality in this division. The AMRs for CVD overall (men, 534 per 100 000 population; women, 413 per 100 000 population) and cerebrovascular disease (men, 73 per 100 000 population; women, 81 per 100 000 population) were highest in the East South Central division as compared with all of the Census divisions (Table 8). However, this pattern was not found for Chinese, Filipino, or Japanese subgroups.

Discussion

To our knowledge, this is one of the first studies to investigate geographical patterns of CVD mortality among Asian American subgroups in the United States. Although our study cannot specifically test the relative contribution of the processes leading to regional differences in CVD mortality among Asian American subgroups, our description of these differences is a first step toward understanding the importance of environmental context and migration patterns for influencing CVD mortality in these populations. Our analysis showed that the geographical variation in CVD mortality among Asian American subgroups and across CVD subtypes was largely similar to non-Hispanic whites. This suggests that differential migration to particular parts of the country by different Asian American subgroups is not likely to be the primary explanation for geographical differences in cardiovascular health for Asian American subgroups. However, this was not universal. For some Asian American subgroups, we found different geographical patterns. The Pacific division was consistently identified as having the highest AMRs of CVD and CVD subtypes among most Asian American subgroups, followed by the Mid-Atlantic division. Approximately 80% of Filipino CVD deaths and 90% of Japanese CVD deaths occur in the Pacific division. Geographical clustering of CVD mortality among Asians in this division may provide direct evidence of culturally related environmental factors in this specific geographical area or in differential patterns of migration. It is also noteworthy that we observed heterogeneity in CVD mortality rates across the 6 largest Asian American subgroups. Currently, Asian American subgroups have often been aggregated together in national statistics, and this study helps to confirm the importance of using disaggregated data. Although Asians are often thought to be healthier than other minority groups and non-Hispanic whites, special attention should be paid to Asian American subgroups with established higher CVD risk, such as Asian Indians, Japanese, and Filipinos.[6]

Another interesting finding was that Asian American subgroups may have similar or even greater disease burden from cerebrovascular disease compared with non-Hispanic whites, depending on the census division of residence. In particular, Filipino men and women and Japanese men had higher age-adjusted mortality rates of cerebrovascular disease compared with their non-Hispanic white counterparts in the Pacific, West North Central, and Mountain divisions, respectively. Compared with non-Hispanic whites, Filipino men in the Pacific division had 18% higher risk and Japanese men had 5% higher risk in the Pacific division of dying from cerebrovascular disease after standardizing rates for differences in age distribution. Previous studies have demonstrated that hypertension prevalence was higher in Filipino, Japanese, and Vietnamese populations in the United States,[14] but the geographical variation in relative CVD mortality across racial/ethnic groups has not been previously reported. Further research is needed

Table 8. Age-Adjusted CVD Mortality Rates Per 100 000 Population in the East South Central Division by Sex and Race/Ethnicity, 2003–2011

	NHW			Chinese			Filipino			Japanese		
	CVD	Ischemic	Cerebro	CVD	Ischemic	Cerebro	CVD	Ischemic	Cerebro	CVD	Ischemic	Cerebro
Male	534	286	73	182	74	44	304	156	61	141	98	0
Female	413	175	81	168	48	54	167	62	39	90	36	22

CVD indicates cardiovascular disease; NHW, non-Hispanic white.

regarding hypertension treatment and management of cerebrovascular disease among these Asian American subgroups, which may need to account for geographical variation.

Underlying causes of the observed variation across racial/ethnic groups and geographical divisions remain unknown and could not be tested in our analysis. Potential contributing factors include genetic predispositions, environmental interactions, cultural practice/lifestyle, and immigration history, with all of these explanations attributed to either selective migration or the effects of place. Work on geographical differences for genetic risk of CVD has found to have very little variation for non-Hispanic whites, making this explanation seem unlikely, but this has not been examined among Asian Americans.[15] The Ni-Hon-San study investigated CVD rates and risk factors among Japanese men living in 3 cities: Hiroshima, Japan, Honolulu, Hawaii, and San Francisco, California. It showed that coronary heart disease and stroke mortality rates were highest among California participants, followed by Hawaii, and lowest among participants living in Japan.[16] It provides important evidence that populations with a common ethnic background had different CVD outcomes potentially attributed to exposure to different geographical and cultural environments. Similar to this study, we also found variations of CVD mortality rates across Census divisions within Asian American subgroups. Additionally, we found geographical variation in CVD among Asian American subgroups when compared with non-Hispanic whites from the same geographical area. In particular, a greater CVD burden was observed in the Pacific and Mountain divisions, whereas comparable or lower burden was found in the traditional stroke belt. This suggests that environmental factors may impact Asian Americans differentially and adds to the existing body of literature that demonstrates the interaction and influence that built environments play on health outcomes for all racial/ethnic groups. To address these questions, future studies should test whether county-level social, economic, health services, environmental, and demographic factors explain survival differences in CVD between Asian American subgroups and as compared with non-Hispanic whites.

There are several considerations when interpreting these findings. First, we used information from the national death records to identify deaths caused by CVD, which is subject to misclassification. Although this is the best available information, we should be aware of the challenge of determining the underlying causes of death, in particular for different CVD subgroups. A previous study indicates potential errors and inaccuracy of race/ethnicity information on death certificates.[17] This could lead to an over- or underestimate of CVD mortality rates among the racial/ethnic subgroups. Second, our analysis is limited to the Census divisions because of insufficient information at any smaller geographical unit. Thus, we were not able to further explore more granular-level geographical variations within the Census divisions (eg, county level). It is possible that there are additional geographical variations uncaptured by the geographical unit of the Census division. Furthermore, the observed differences in CVD mortality were not adjusted for several important baseline characteristics, including comorbidities and socioeconomic status because of limited data availability. Finally, information about Asian American subgroups in the East South Central division, where CVD is especially prevalent among non-Hispanic white and black populations, was unavailable because of sparse data as a result of late adoption of the 2003 standard of death certificate in the states in this division, and there are relatively fewer Asian Americans overall in this region.

Conclusion

In this analysis, we characterized geographical variation in CVD mortality in Asian American subgroups and provided critical documentation of the geographical burden of CVD in the United States. An important strength of this study is the full national mortality data disaggregated by Asian American subgroups, Census division, and CVD subtype, providing an opportunity to detect the potential impact of geographical factors on CVD mortality among these understudied Asian American subgroup populations. Geographical patterns for CVD overall and ischemic heart disease were mostly similar for Asian American subgroups compared with non-Hispanic whites, but there were substantial differences for cerebrovascular disease. In particular, there were higher mortality rates for Filipino men and Japanese men in the Pacific division, the division of the country with the largest population of these groups. These findings lead to new directions for etiological research for geographically related causes of CVD and, in this case, how these contributing factors may be differentially impacting cerebrovascular disease in certain Asian American subgroups. It can also help prioritize resources of prevention and treatment to areas of the country where they are most needed.

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Disclosures

None.

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