Lung Cancer Deaths Among American Indians and Alaska Natives, 1990–2009

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Objectives. We examined regional differences in lung cancer among American Indians/Alaska Natives (AI/ANs) using linked data sets to minimize racial misclassification.

Methods. On the basis of federal lung cancer incidence data for 1999 to 2009 and deaths for 1990 to 2009 linked with Indian Health Service (IHS) registration records, we calculated age-adjusted incidence and death rates for non-Hispanic AI/AN and White persons by IHS region, focusing on Contract Health Service Delivery Area (CHSDA) counties. We correlated death rates with cigarette smoking prevalence and calculated mortality-to-incidence ratios.

Results. Lung cancer death rates among AI/AN persons in CHSDA counties varied across IHS regions, from 94.0 per 100 000 in the Northern Plains to 15.2 in the Southwest, reflecting the strong correlation between smoking and lung cancer. For every 100 lung cancers diagnosed, there were 6 more deaths among AI/AN persons than among White persons. Lung cancer death rates began to decline in 1997 among AI/AN men and are still increasing among AI/AN women.

Conclusions. Comparison of regional lung cancer death rates between AI/AN and White populations indicates disparities in tobacco control and prevention interventions. Efforts should be made to ensure that AI/AN persons receive equal benefit from current and emerging lung cancer prevention and control interventions. (*Am J Public Health.* 2014;104:S388–S395. doi:10.2105/AJPH.2013.301609)

Lung cancer is the leading cause of cancer death in the United States.[1] It is the most commonly diagnosed cancer among men and women combined and is associated with very low survival rates. [2] More than 90% of deaths from lung cancer are caused by cigarette smoking and exposure to secondhand smoke.[3] Efforts to reduce lung cancer mortality have focused on the primary prevention of environmental risk factors and exposures, and public health efforts to limit tobacco exposure have effectively reduced the lung cancer burden among men and women in the United States.[3] Lung cancer is a particularly important public health issue among American Indians/Alaska Natives (AI/ANs) because they typically report higher prevalence of daily cigarette use and their declines in tobacco use have lagged behind those of other racial/ethnic groups.[4]

Historically, screening technologies have had limited impact on lung cancer mortality. Now, low-dose computerized tomography (CT) scans for the early detection of lung cancer in individuals with a significant history of tobacco use are an emerging cancer control strategy.[5] However, unless adequate infrastructure, technical capacity, and access to treatment are in place, lack of access to these screening methods may have a disproportionate impact on the AI/AN population as a result of the greater rural distribution and lower rates of health insurance coverage of this population.[6]

Comparison of lung cancer mortality between AI/AN and White persons can serve as an important indicator of disparities in the quality of risk reduction interventions, access to care, and quality and timeliness of treatment options. However, misclassification of AI/AN race is common in both state and national databases.[7] The Indian Health Service (IHS) patient registration database contains records of individuals who are members of federally recognized tribes. Linking these data with incidence and mortality data has helped correct some of the race misclassification in these data sets.[7] In this article, we examine national, geographic, and demographic trends in AI/AN lung cancer mortality from 1990 to 2009 using a linked data set to address previous misclassification. We correlate our findings with trends in tobacco use and lung cancer mortality and discuss the implications for comprehensive tobacco control and lung cancer screening.

METHODS

Detailed methods for generating the analytic mortality and incidence files are described elsewhere in this supplement.[8,9] Abbreviated methods follow.

Data Sources

Population estimates. Bridged single-race population estimates developed by the US Census Bureau and the Centers for Disease Control and Prevention's National Center for Health Statistics (NCHS) and adjusted for the population shifts resulting from Hurricanes Katrina and Rita in 2005 are included as denominators in the calculations of death and incidence rates.[10,11] Bridged single-race data allow for comparability between the pre- and post-2000 race/ethnicity population estimates during this study period. During preliminary analyses, it was discovered that the updated bridged intercensal population estimates significantly overestimated AI/AN persons of Hispanic origin.[12] Therefore, to avoid underestimating mortality and incidence in AI/AN persons, analyses were limited to non-Hispanic AI/AN persons. Non-Hispanic White was chosen as the most homogeneous referent group. For conciseness, the qualifying term "non-Hispanic" is omitted when discussing both groups henceforth.

Death records. Death certificate data are compiled by each state and sent to the NCHS, where they are edited for consistency and stripped of personal identifiers. The NCHS makes this information available to the research community as part of the National Vital Statistics System and includes underlying and multiple cause-of-death fields, state of residence, age, gender, race, and ethnicity.[13] The National Vital Statistics System applies a bridging algorithm nearly identical to that used by the Census Bureau to assign a single race to decedents with multiple races reported on the death certificate.[14]

The IHS patient registration database was linked to death certificate data in the National Death Index to identify AI/AN deaths misclassified as non-Native.[7] After this linkage, a flag indicating a positive link to IHS was added as an additional variable to the NVSS mortality file to indicate AI/AN ancestry. This file was combined with the population estimates to create an analytic file in SEER*Stat software, version 8.02 (http://seer.cancer.gov/seerstat; National Cancer Institute, Bethesda, MD), which includes all deaths for all races reported to NCHS from 1990 to 2009. Race for AI/AN deaths in this article is assigned as reported elsewhere in this supplement.[8] In short, it combines race classification by NCHS on the basis of the death certificate and information derived from data linkages between the IHS patient registration database and the National Death Index.

For 1990 to 1998, we coded the underlying cause of death according to the *International Classification of Diseases, Ninth Revision* (*ICD-9*).[15] For 1999 to 2009, we used the *International Classification of Diseases, 10th Revision* (*ICD-10*).[16] For deaths occurring from 1990 to 1998, we converted *ICD-9* codes to *ICD-10* codes to ease comparisons across the 2 periods. For deaths resulting from lung cancer, we used *ICD-10* code C34.

Incidence data. Incident cancer cases diagnosed during 1999 to 2009 were identified from population-based, central cancer registries that participate in the Centers for Disease Control and Prevention's National Program of Cancer Registries and the National Cancer Institute's Surveillance, Epidemiology, and End Results Program.[17,18] For data to be included for a given year, registries had to meet data standards developed for US Cancer Statistics.[14] Participating registries classified tumor histology, tumor behavior, and primary cancer site according to the third edition of the International Classification of Diseases for Oncology (*ICD-O-3*).[19]

We present incidence rates for lung cancer (*ICD-O-3* code C34) among AI/AN populations nationwide; the site category is consistent with prevailing reporting standards. We did not include lymphomas (*ICD-O-3* histology codes 9590–9729), mesothelioma (*ICD-O-3* histology codes 9050–9055), and Kaposi sarcoma (*ICD-O-3* histology code 9140) in this analysis. Only malignant tumors (*ICD-O-3* behavior code 3) were included in this analysis.

To identify AI/AN cancer cases misclassified as other races, central cancer registries linked cancer registry records with IHS patient registration files as previously described.[8]

Geographic coverage. To create most of the tabulations in this article, we restricted the analyses to Contract Health Service Delivery Area (CHSDA) counties that, in general, contain federally recognized tribal lands or are adjacent to tribal lands.[8] The IHS uses CHSDA residence to determine eligibility for services not directly available within the IHS. Linkage studies have identified less misclassification of AI/AN race in these counties.[5,20] The CHSDA counties also have higher proportions of AI/AN persons in relation to total population than do non-CHSDA counties, with 64% of the US AI/AN population residing in the 634 counties designated as CHSDA (these counties represent 20% of the 3141 counties in the United States). Although less geographically representative, we present analyses restricted to CHSDA counties for death rates in this article for the purpose of offering improved accuracy in interpreting mortality statistics for AI/AN persons.

The analyses were completed for all regions combined and by individual IHS regions: Northern Plains, Alaska, Southern Plains, Southwest, Pacific Coast, and East.[8] Identical or similar regional analyses have been used for other health-related publications focusing on the AI/AN population,[21–23] and this approach was found to be preferable to the use of smaller jurisdictions, such as the administrative areas defined by IHS,[24] which yielded less stable estimates.

Statistical Methods

All rates, expressed per 100 000 population, were directly age adjusted to the 2000 US standard population (Census P25-1130).[25] Readers should avoid comparison of these data with published death rates adjusted using a different standard population.

Using the age-adjusted death rates, we calculated standardized rate ratios (RRs) for AI/AN populations using rates in Whites for comparison. Rate ratios were rounded for presentation in the tables. We calculated confidence intervals (CIs) for age-adjusted rates and RRs on the basis of methods described by Tiwari et al.[26] We assessed temporal changes in annual age-adjusted death rates, including the annual percentage change (APC) for each interval, with joinpoint regression techniques.[27] All calculations were performed using SEER*Stat version 8.0.2. Too few lung cancer deaths occurred among AI/AN persons living in the Southern Plains to reliably assess annual trends. We calculated the mortality-to-incidence ratio by dividing the age-adjusted death rate by the age-adjusted incidence rate. Confidence intervals were calculated using methods proposed by Fay[28] for directly standardized rates with sparse data. The mortality-to-incidence ratio represents the number of lung cancer deaths per 100 lung cancers diagnosed and is an indication of prognosis after diagnosis.[29] We used Pearson correlation coefficients to evaluate the association between region-specific lung cancer mortality (2003–2009) and cigarette smoking prevalence 3 years prior (2000–2006); analyses were weighted by the inverse variances of the age-adjusted death rates. We selected a 3-year lag for lung cancer mortality to allow use of these published estimates and available years for mortality; estimates of smoking prevalence were from the Behavioral Risk Factor Surveillance System.[30] We also used Pearson correlation coefficients to evaluate the association between region-specific lung cancer mortality trends and differences in smoking prevalence (percentage difference in estimates for 2000–2006 and estimates for 1997–2000).[30,31] All tests of statistical significance were 2 tailed ($P < .05$).

RESULTS

From 1999 to 2009, 8118 AI/AN persons in the United States died from lung cancer. Most of these deaths (68%) occurred among AI/AN persons residing in CHSDA counties. Overall, AI/AN persons had slightly lower rates of death from lung cancer (49.7) than White persons (55.3). When restricted to populations living in CHSDA counties, the lung cancer death rate for AI/AN persons (55.2) was higher than the rate for AI/AN persons in all counties (49.7) and the rate for White persons in CHSDA counties (53.5). The remainder of the results pertains to populations living in CHSDA counties.

Lung cancer death rates among AI/AN persons varied more than 6-fold across IHS regions (Table 1). Rates were highest in the Northern Plains (94.0), Alaska (74.2), and the Southern Plains (78.5) and lowest in the Southwest (15.2). Lung cancer death rates for White persons did not exhibit the same magnitude or pattern of regional variation; rates were highest in the Southern Plains (62.2) and the East (56.0).

AI/AN persons had significantly higher death rates from lung cancer than did White persons (Table 1) in the Northern Plains (RR = 1.86; 95% CI = 1.76, 1.97), Alaska (RR = 1.41; 95% CI = 1.26, 1.56), Southern Plains (RR = 1.26; 95% CI = 1.20, 1.33), and the Pacific Coast (RR = 1.07; 95% CI = 1.00, 1.14). In contrast, lung cancer death rates for AI/AN persons were significantly lower than those for White persons in the East (RR = 0.82; 95% CI = 0.73, 0.92) and Southwest (RR = 0.31; 95% CI = 0.28, 0.34).

By sex, rates of lung cancer death in CHSDA counties were similar between AI/AN and White males, but rates of lung cancer death were slightly higher among AI/AN females (46.2) compared with White females (43.4). By IHS region, lung cancer death rates were higher among AI/AN males than White males in the Northern Plains, Alaska, and Southern Plains; virtually the same in the Pacific Coast; and lower in the East and Southwest. Among females, lung cancer death rates were higher among AI/ANs than Whites in the Northern Plains, Alaska, Southern Plains, and the Pacific Coast and lower in the East and Southwest.

As with many other forms of cancer, lung cancer death rates increased with age, and the highest rates occurred in the oldest age group (Table 2). However, when compared with White persons, AI/AN persons died from lung cancer at younger ages. Among AI/AN persons, 37% of lung cancer deaths occurred at ages younger than 65 years compared with 26% of deaths among White persons ($P < .05$). The lung cancer mortality-to-incidence ratio was 0.83 (83 deaths per 100 lung cancers) among AI/AN persons and 0.77 (77 deaths/100 lung cancers) among White persons; this pattern was similar across regions (data not shown).

Analysis of temporal trends in lung cancer death rates revealed significant disparities by gender (Figure 1). Male A/IAN lung cancer death rates increased from 1990 through 1997, peaked in 1997, and decreased nonsignificantly from 1997 through 2009 (APC 1997–2009 = −1.0). In White males, lung cancer death rates decreased significantly over the whole time period (APC 1990–2003 = −1.5; $P < .05$; APC 2003–2009 = −2.6; $P < .05$). Because of these differences in trends, AI/AN males had lower lung cancer death rates than White males at the beginning of the period and higher rates toward the end. Lung cancer death rates decreased among AI/AN males in all IHS regions except the East (and could not be assessed in the Southern Plains). Among White females, lung cancer death rates peaked in 2001 and then declined through 2009 (APC 1990–2001 = 1.0; $P < .05$; APC 2001–2009 = −1.0; $P < .05$). Rates for AI/AN females continued to increase throughout the 1990 to 2009 time period (APC 1990–2009 = 2.4; $P < .05$), and the rate for AI/AN females is now higher than the rate for White females. Lung cancer death rates increased among AI/AN females in all IHS regions except the Northern Plains (and could not be assessed in the Southern Plains).

The distribution of smoking prevalence rates among AI/AN persons varied widely across IHS regions (Figure 2); current smoking prevalence from 2000 to 2006 was highest in the Northern Plains and Alaska (40%) and lowest in the Southwest and Pacific Coast (21%). We found a strong correlation between lung cancer mortality and smoking prevalence 3 years prior for AI/AN persons across IHS regions ($r = .85$; $P < .05$) such that regions with high smoking prevalence tended to have high lung cancer death rates. Although lung cancer mortality tended to decrease in regions in which smoking prevalence decreased, the modest correlation between lung cancer mortality trends and changes in smoking prevalence across IHS regions was not statistically significant ($r = .51$; $P = .13$).

DISCUSSION

This is the most comprehensive study of the mortality of lung cancer among AI/AN populations in the United States to date. Linking mortality data from NCHS to the IHS patient registration database improved classification of race among AI/AN persons and provided the opportunity to more accurately describe both regional and national estimates of lung cancer mortality for AI/AN persons. Our findings confirmed the dramatic regional differences in lung cancer rates that have been reported in studies using death certificates alone.[23] Lung cancer death rates in AI/AN persons varied 6-fold across IHS regions (in CHSDA counties), with the highest rates observed in the Northern and Southern Plains and Alaska and the lowest rates observed in the Southwest. These rates were closely correlated with similar differences in tobacco use among the IHS regions. Reductions in lung cancer mortality have lagged behind those seen for White males, and rates are still increasing in AI/AN females. Across all regions, lung cancer appears more rapidly fatal in AI/AN males and females than in White males and females.

Cigarette smoking and exposure to environmental tobacco have been linked directly to lung cancer and many other diseases, including heart disease, stroke, and multiple cancers.[2,32] Tobacco use data for AI/AN persons must be interpreted with caution because many AI/AN persons use tobacco for traditional or ceremonial purposes and may not be habitual smokers.[33] Nevertheless, we have found that the greatest burden of lung cancer is correlated with the IHS regions with the highest prevalence of tobacco use. Variations among states and racial groups in temporal trends of lung cancer incidence are influenced by variations in cigarette smoking behavior.[34] We found that, although not statistically significant, regions in which smoking prevalence decreased tended to also experience decreases in lung cancer mortality, whereas regions in which smoking prevalence increased tended to also experience increases in lung cancer mortality.

Tobacco control strategies to prevent initiation, reduce consumption, and promote cessation have been shown to be correlated with declines in lung cancer incidence and mortality.[35–37] Lung cancer incidence rates have been shown to decline as soon as 5 years after smoking rates decline.[35] These efforts are reflected in the general US population, where in the past decade lung cancer incidence and mortality

TABLE 1—Death Rates for Cancer of the Lung and Bronchus by IHS Region and Sex for AI/AN Persons Compared With White Persons: United States, 1999–2009

	CHSDA Counties				All Counties			
IHS Region and Sex	AI/AN Count	AI/AN Rate	White Rate	AI/AN:White RR (95% CI)	AI/AN Count	AI/AN Rate	White Rate	AI/AN:White RR (95% CI)
Northern Plains								
Male and female	1351	94.0	50.5	1.86* (1.76, 1.97)	1881	82.8	53.0	1.56* (1.49, 1.64)
Male	679	113.4	66.2	1.71* (1.57, 1.87)	946	100.7	69.2	1.45* (1.35, 1.57)
Female	672	81.6	38.7	2.11* (1.94, 2.28)	935	71.7	41.3	1.74* (1.62, 1.86)
Alaska								
Male and female	489	74.2	52.8	1.41* (1.26, 1.56)	489	74.2	52.8	1.41* (1.26, 1.56)
Male	273	89.2	62.4	1.43* (1.23, 1.66)	273	89.2	62.4	1.43* (1.23, 1.66)
Female	216	61.9	44.9	1.38* (1.17, 1.61)	216	61.9	44.9	1.38* (1.17, 1.61)
Southern Plains								
Male and female	1856	78.5	62.2	1.26* (1.20, 1.33)	2187	70.4	57.8	1.22* (1.16, 1.27)
Male	1032	102.1	83.6	1.22* (1.14, 1.31)	1216	90.0	76.1	1.18* (1.11, 1.26)
Female	824	61.8	46.2	1.34* (1.24, 1.44)	971	56.2	44.1	1.27* (1.19, 1.36)
Southwest								
Male and female	433	15.2	48.9	0.31* (0.28, 0.34)	531	17.3	44.7	0.39* (0.35, 0.42)
Male	241	20.1	58.6	0.34* (0.30, 0.39)	288	22.2	54.3	0.41* (0.36, 0.46)
Female	192	11.6	41.0	0.28* (0.24, 0.33)	243	13.7	37.2	0.37* (0.32, 0.42)
Pacific Coast								
Male and female	1060	57.2	53.3	1.07* (1.00, 1.14)	1437	51.3	50.7	1.01 (0.96, 1.07)
Male	506	62.3	63.7	0.98 (0.89, 1.08)	701	56.7	60.2	0.94 (0.87, 1.02)
Female	554	53.8	45.5	1.18* (1.08, 1.29)	736	47.7	43.7	1.09* (1.01, 1.18)
East								
Male and female	338	46.1	56.0	0.82* (0.73, 0.92)	1593	36.6	57.9	0.63* (0.60, 0.67)
Male	190	58.8	71.7	0.82* (0.69, 0.96)	924	47.6	76.0	0.63* (0.58, 0.67)
Female	148	37.0	44.5	0.83* (0.70, 0.98)	669	28.3	44.7	0.63* (0.58, 0.68)
Total								
Male and female	5527	55.2	53.5	1.03* (1.00, 1.06)	8118	49.7	55.3	0.90* (0.88, 0.92)
Male	2921	67.5	67.0	1.01 (0.97, 1.05)	4348	61.0	71.5	0.85* (0.83, 0.88)
Female	2606	46.2	43.4	1.06* (1.02, 1.11)	3770	41.5	43.5	0.95* (0.92, 0.99)

Note. AI/ANs = American Indians/Alaska Natives; CHSDA = Contract Health Service Delivery Areas; CI = confidence interval; IHS = Indian Health Service; RR = rate ratio. Analyses were limited to persons of non-Hispanic origin. AI/AN race was created using death certificate race and IHS Link. Rates are per 100 000 persons, age-adjusted to the 2000 US standard population (11 age groups; Census P25-1130).[25] RRs were calculated in SEER*Stat before rounding of rates and may not equal RRs calculated from rates presented in the table. Cancer causes of death were created using the SEER cause-of-death recode. States and years of data excluded because Hispanic origin was not collected on the death certificate: LA, 1990; NH, 1990–1992; and OK, 1990–1996. IHS regions are defined as follows: Alaska[a]; Northern Plains (IL, IN,[a] IA,[a] MI,[a] MN,[a] MT,[a] NE,[a] ND,[a] SD,[a] WI,[a] WY[a]); Southern Plains (OK,[a] KS,[a] TX[a]); Southwest (AZ,[a] CO,[a] NV,[a] NM,[a] UT[a]); Pacific Coast (CA,[a] ID,[a] OR,[a] WA,[a] HI); and East (AL,[a] AR, CT,[a] DE, FL,[a] GA, KY, LA,[a] ME,[a] MD, MA,[a] MS,[a] MO, NH, NJ, NY,[a] NC,[a] OH, PA,[a] RI,[a] SC,[a] TN, VT, VA, WV, DC). Percentage regional coverage of AI/ANs in CHSDA counties to AI/ANs in all counties: Northern Plains = 64.8%; Alaska = 100%; Southern Plains = 76.3%; Southwest = 91.3%; Pacific Coast = 71.3%; East = 18.2%; and total US = 64.2%.
Source. AI/AN Mortality Database (1990–2009).
[a]Identifies states with ≥ 1 county designated as CHSDA.
*$P < .05$.

have decreased substantially among US men and progress is now being observed among US women.[1] We found that lung cancer mortality trends for AI/AN communities lag behind those of Whites. Reversal of increasing death rates for lung cancer occurred 10 years later for AI/AN males and has still not been documented for AI/AN females. In addition, although tobacco use among AI/AN and White populations has decreased, AI/AN populations continue to report a higher prevalence of tobacco use than White populations.[36] Effective tobacco control prevention and control policies can decrease smoking prevalence and exposure to secondhand smoke, which ultimately leads to decreases in lung cancer.[37] However, only 2 of the 562 federally recognized tribes have adopted comprehensive commercial tobacco-free ordinances on their reservations,[38] and exposure to secondhand smoke is a significant concern in tribally owned casinos and gaming venues that are a source of employment for many AI/AN persons.[39,40]

Until recently, treatment options for lung cancer were limited, and early detection was not recommended.[41] However, 2011 data from the National Lung Cancer Screening Trial

TABLE 2—Death Rates for Cancer of the Lung and Bronchus by IHS Region (CHSDA Counties Only) and Age for AI/AN Persons Compared With White Persons: United States, 1999–2009

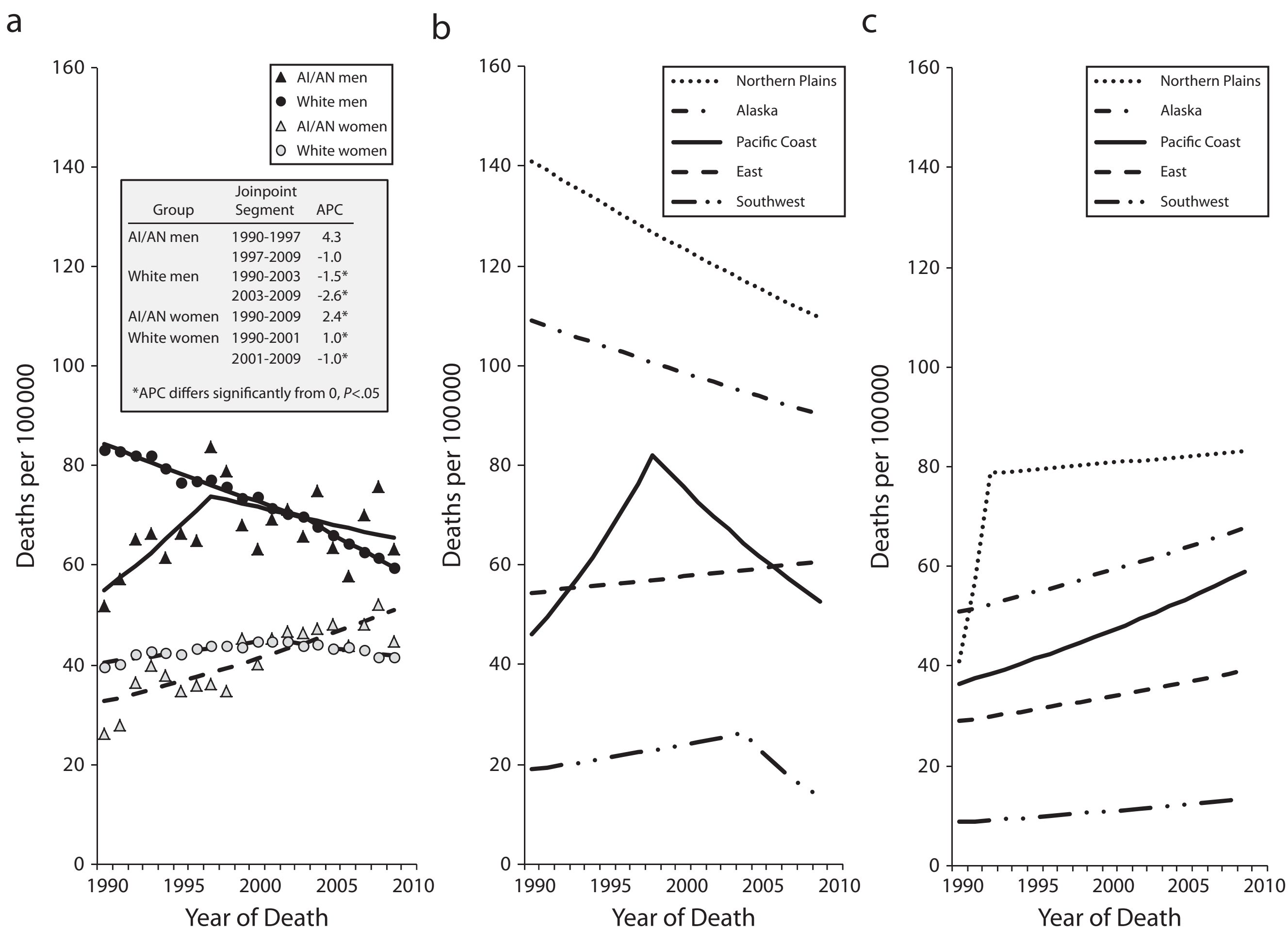
	Aged < 50 Years			Aged 50–64 Years			Aged 65–74 Years			Aged ≥ 75 Years		
IHS Region	% Deaths	Rate	RR (95% CI)	% Deaths	Rate	RR (95% CI)	% Deaths	Rate	RR (95% CI)	% Deaths	Rate	RR (95% CI)
AI/AN												
Northern Plains	5	3.9	1.29* (1.00, 1.64)	30	121.7	1.66* (1.50, 1.83)	39	524.2	2.06* (1.88, 2.24)	26	656.6	1.93* (1.73, 2.15)
Alaska	4	2.6	1.20 (0.70, 1.95)	31	108.3	1.69* (1.40, 2.02)	37	399.1	1.45* (1.22, 1.72)	28	504.1	1.26* (1.03, 1.52)
Southern Plains	6	5.3	1.33* (1.09, 1.61)	32	121.5	1.23* (1.13, 1.34)	33	382.0	1.23* (1.13, 1.34)	29	527.6	1.33* (1.22, 1.45)
Southwest	4	0.6	0.23* (0.13, 0.35)	26	18.7	0.27* (0.22, 0.33)	34	74.4	0.31* (0.26, 0.37)	35	120.3	0.35* (0.29, 0.41)
Pacific Coast	5	2.5	0.97 (0.72, 1.27)	31	72.4	1.02 (0.91, 1.13)	35	292.6	1.09 (0.98, 1.21)	29	430.6	1.13* (1.00, 1.26)
East	7	3.1	0.85 (0.55, 1.26)	33	65.8	0.79* (0.65, 0.95)	31	218.0	0.79* (0.65, 0.96)	29	329.3	0.88 (0.72, 1.08)
Overall	6	2.8	0.91 (0.81, 1.02)	31	77.6	1.01 (0.96, 1.06)	35	284.7	1.07* (1.02, 1.12)	29	385.9	1.05 (1.00, 1.10)
White												
Northern Plains	4	3.0		23	73.2		32	255.0		41	339.9	
Alaska	5	2.2		32	64.2		32	274.4		30	401.5	
Southern Plains	4	4.0		25	99.0		33	310.2		38	396.2	
Southwest	3	2.5		23	68.8		33	238.4		41	347.4	
Pacific Coast	3	2.6		22	71.3		31	269.1		44	381.8	
East	4	3.6		23	83.8		31	276.0		42	373.1	
Overall	3	3.0		23	76.7		32	266.8		42	368.2	

Note. AI/ANs = American Indians/Alaska Natives; CHSDA = Contract Health Service Delivery Areas; CI = confidence interval; IHS = Indian Health Service; RR = rate ratio. Data used were from CHSDA counties only. Analyses were limited to persons of non-Hispanic origin. AI/AN race was created using death certificate race and IHS Link. Rates are per 100 000 persons, age-adjusted to the 2000 US standard population (11 age groups; Census P25-1130).[25] RRs were calculated in SEER*Stat before rounding of rates and may not equal RRs calculated from rates presented in the table. Cancer causes of death were created using the SEER cause-of-death recode. IHS regions are defined as follows: Alaska[a]; Northern Plains (IL, IN,[a] IA,[a] MI,[a] MN,[a] MT,[a] NE,[a] ND,[a] SD,[a] WI,[a] WY[a]); Southern Plains (OK,[a] KS,[a] TX[a]); Southwest (AZ,[a] CO,[a] NV,[a] NM,[a] UT[a]); Pacific Coast (CA,[a] ID,[a] OR,[a] WA,[a] HI); and East (AL,[a] AR, CT,[a] DE, FL,[a] GA, KY, LA,[a] ME,[a] MD, MA,[a] MS,[a] MO, NH, NJ, NY,[a] NC,[a] OH, PA,[a] RI,[a] SC,[a] TN, VT, VA, WV, DC). Percentage regional coverage of AI/AN persons in CHSDA counties to AI/AN persons in all counties: Northern Plains = 64.8%; Alaska = 100%; Southern Plains = 76.3%; Southwest = 91.3%; Pacific Coast = 71.3%; East = 18.2%; and total US = 64.2%.
Source. AI/AN Mortality Database (1990–2009).
[a]Identifies states with ≥ 1 county designated as CHSDA.
*$P < .05$.

demonstrated screening with helical CT scans was associated with a 20% reduction in mortality from lung cancer among individuals with a strong history of tobacco use.[5] On the basis of the results of the National Lung Cancer Screening Trial, several professional associations and the American Cancer Society have made joint recommendations that support lung cancer screening with helical CT scans following the general National Lung Cancer Screening Trial protocol.[42,43] The US Preventive Services Task Force has issued a Grade B recommendation that supports annual screening for lung cancer with low-dose CT scans in persons at high risk for lung cancer on the basis of age and smoking history.[41]

This analysis suggests that AI/AN persons diagnosed with lung cancer die more rapidly than White persons. Similar findings have been demonstrated for other racial and ethnic minorities.[44,45] If lung cancer screening becomes accepted as an evidence-based standard of care, efforts should be taken to ensure that AI/AN populations receive equal benefit from screening so that the current disparities do not become even greater. Possible widespread uptake of lung cancer screening may depend on availability of insurance reimbursement and access to facilities capable of providing quality screening and interpretation of tests. However, previous studies have found that AI/AN populations encounter significant barriers to cancer screening because of geographic isolation and socioeconomic conditions.[6] The prevalence of screening for breast, cervical, and colorectal cancer has been lower among AI/AN populations than White populations.[46–48] Previous studies have documented that AI/AN persons are more likely than White persons to be diagnosed with late-stage breast and colorectal cancer.[49,50] These lower screening prevalence estimates suggest that lung cancer screening may not be well used in AI/AN communities without additional efforts to develop accessible screening programs and aggressive outreach.

In addition, the capacity of the IHS to provide CT scans may be variable. In some areas, CT scans are not available through local IHS facilities and must be performed through regional hospitals or through referral contracts that often require special approval. Furthermore, lung cancer screening may be most effective if delivered in settings with adequate technology and diagnostic training. The rate of false positive findings in the National Lung Cancer Screening Trial[5] was significant, and it is important that findings are not overinterpreted. Our data indicate that the number of patients who are current smokers and will be eligible for lung cancer screening will vary significantly across CHSDA regions. Planners could analyze tobacco use data to estimate the number of AI/AN persons eligible for screening



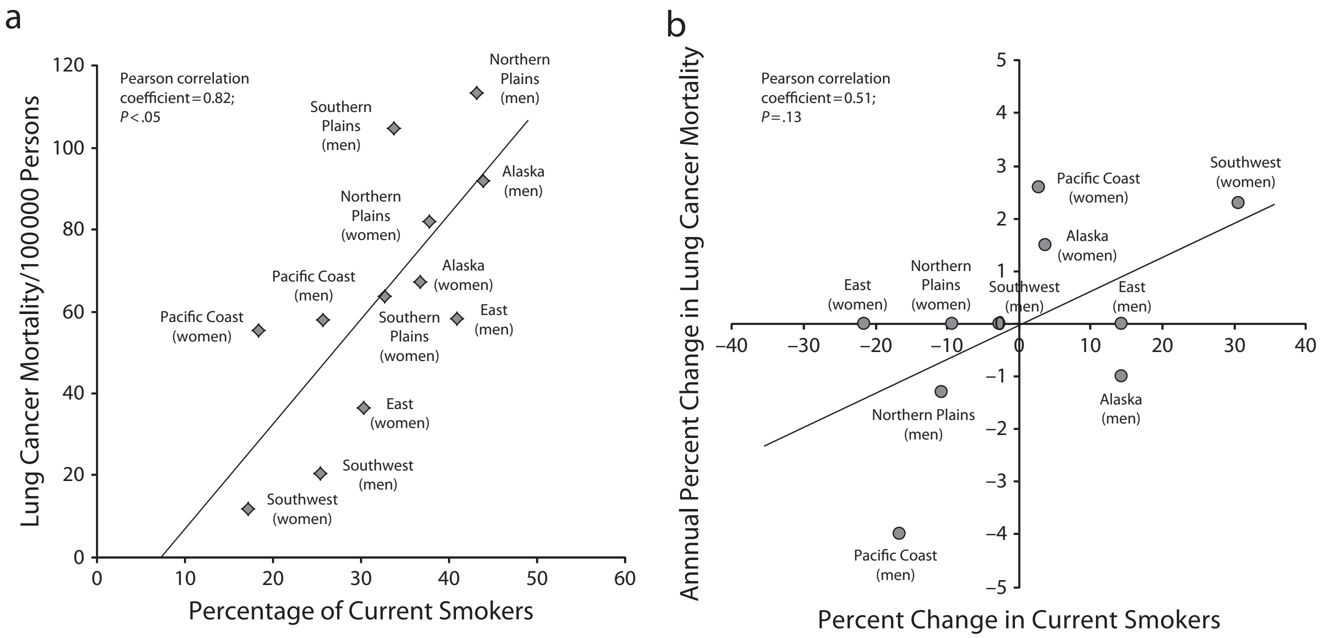
Note. AI/AN = American Indian/Alaska Natives; CHSDA = Contract Health Service Delivery Area; IHS = Indian Health Service. The following states and years of data were excluded because Hispanic origin was not collected on the death certificate: LA, 1990; NH, 1990–1992; and OK, 1990–1996. IHS regions are defined as follows: Alaska;[a] Northern Plains (IL, IN,[a] IA,[a] MI,[a] MN,[a] MT,[a] NE,[a] ND,[a] SD,[a] WI,[a] WY[a]); Southwest (AZ,[a] CO,[a] NV,[a] NM,[a] UT[a]); Pacific Coast (CA,[a] ID,[a] OR,[a] WA,[a] HI); and East (AL,[a] AR, CT,[a] DE, FL,[a] GA, KY, LA,[a] ME,[a] MD, MA,[a] MS,[a] MO, NH, NJ, NY,[a] NC,[a] OH, PA,[a] RI,[a] SC,[a] TN, VT, VA, WV, DC). Percentage regional coverage of AI/AN persons in CHSDA counties to AI/AN persons in all counties: Northern Plains = 64.8%; Alaska = 100%; Southwest = 91.3%; Pacific Coast = 71.3%; East = 18.2%; total US = 64.2%.
Source. AI/AN Mortality Database (1990–2009).
[a]Identifies states with ≥ 1 county designated as CHSDA.

FIGURE 1—Trends in lung and bronchus cancer death rates in CHSDA counties by (a) overall US rates by sex, (b) rates among AI/AN men by IHS region and (c) and rates among AI/AN women by IHS region: United States, 1990–2009.

in each region and develop capacity to meet these predicted needs.

Our data suggest that lung cancer screening programs for AI/AN persons who are current smokers may be most effective when paired with structured, evidence-based tobacco cessation counseling as well as assurance of appropriate follow-up and access to smoking cessation treatment. It is important that publicity for a potential screening program and its related educational materials is provided in plain language that smokers will understand. Specifically, the benefits of increased longevity from screening are small relative to the benefits of quitting; quitting is the most effective way to lower lung cancer risk and other health risks, such as heart disease, stroke, and chronic pulmonary disease.

Our findings are subject to several limitations. First, some rates were based on relatively small numbers. In addition, most analyses were restricted to CHSDA counties, in which only 64% of AI/AN persons live and which tend to be located in more rural areas and Western states. Therefore, the results may not be generalizable to all AI/AN (or White) persons in the United States. Second, although linkage with the IHS patient registration database improved the classification of race for many AI/AN decedents, the issue is not completely resolved because AI/AN persons who are not members of federally recognized tribes are not eligible for IHS services and not represented in the IHS registration database.[22] Third, substantial variation exists between federally recognized tribes in the proportion of native



Note. BRFSS = Behavior Risk Factor Surveillance System; IHS = Indian Health Service. Pearson correlation coefficients weighted by inverse variance of mortality rate/trend.
Source. Kim et al.,[27] Fay.[28]

FIGURE 2—Correlation between (a) cigarette smoking prevalence (BRFSS 2000–2006) and lung cancer death rates (2003–2009) by IHS region and (b) changes in cigarette smoking prevalence (BRFSS 1997–2000 and BRFSS 2000–2006) and trends in lung cancer death rates (2000–2009) by IHS region for American Indians and Alaska Natives: United States.

ancestry required for tribal membership and therefore for eligibility for IHS services. Whether and how this discrepancy in tribal membership requirements may influence some of our findings is unclear, although our findings are consistent with prior reports. Finally, although the exclusion of Hispanic AI/AN persons from the analyses reduced the overall AI/AN deaths by less than 5%, it may disproportionately exclude some tribal members in states along the US–Mexico border and possibly elsewhere who have Hispanic surnames and may be coded as Hispanic at death.

In conclusion, lung cancer is a significant problem for a large portion of AI/AN populations, notably those who live in the Northern Plains and Alaska where dramatic disparities in lung cancer death rates exist between AI/AN and White populations. The 6-fold difference between the lowest and highest lung cancer death rates (Southwest vs Northern Plains) reflects the strong association between cigarette smoking and the development of lung cancer. Our study underscores the need for comprehensive tobacco control programs within AI/AN populations and communities. In addition, the emerging use of low-dose CT scanning to screen heavy smokers for lung cancer may also reduce death from lung cancer among AI/AN populations but will require adequate infrastructure, technical capacity, and outreach.

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Contributors

M. Plescia led the conceptualization and design of the article and the preparation of the first draft and all revisions. S. J. Henley led the analysis and interpretation of the data, provided statistical expertise, and made critical revisions to the article for important intellectual content. A. Pate helped prepare the first draft of the article and made critical revisions to the article for important intellectual content. J. M. Underwood expanded the literature review for the article and made critical revisions to the article for important intellectual content. K. Rhodes provided context on American Indian/Alaska Native public health programming for the article and made critical revisions to the article for important intellectual content. All authors approved the final version.

Human Participant Protection

Because the study did not involve human participants, institutional review board approval was not necessary.

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