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Smoking-Attributable Mortality in American Indians: Findings from the Strong Heart Study

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Abstract

Cigarette smoking is the leading preventable cause of death worldwide. American Indians have the highest proportion of smoking in the United States. However, few studies have examined the impact of cigarette smoking on disease mortality in this ethnically important but traditionally understudied minority population. Here we estimated the association of cigarette smoking with cardiovascular disease (CVD), cancer and all-cause mortality in American Indians participating in the Strong Heart Study (SHS), a large community-based prospective cohort study comprising of 4,549 American Indians (aged 45–74 years) followed for about 20 years (1989–2008). Hazard ratio and population attributable risk (PAR) associated with cigarette smoking were estimated by Cox proportional hazard model, adjusting for sex, study site, age, educational level, alcohol consumption, physical activity, BMI, lipids, renal function, hypertension or diabetes status at baseline, and interaction between current smoker and study site. We found that current smoking was significantly associated with cancer mortality (HR 5.0, [1.9–13.4]) in men, (HR 3.9 [1.6–9.7] in women) and all-cause mortality (HR 1.8, [1.2–2.6] in men, HR 1.6, [1.1–2.4] in women). PAR for cancer and all-cause mortality in men were 41.0% and 18.4%, respectively, whereas the corresponding numbers in women were 24.9% and 10.9%, respectively. Current smoking also significantly increases the risk of CVD deaths in women (HR 2.2 [1.1, 4.4]), but not men (HR 1.2

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Contributors

J.Z led the conceptualization, data analyses, interpretation of findings, and writing the article. M.Z and Q.A conducted data analyses and contributed to draft the manuscript. F.Y, Y.Z, E.T.L and B.V.H contributed to discussion, reviewed and edited the manuscript.

Competing interests

None

[0.6–2.4]). PAR for CVD mortality in women was 14.9%. In summary, current smoking significantly increases the risk of CVD (in women), cancer and all-cause mortality in American Indians, independent of known risk factors. Culturally specific smoking cessation programs are urgently needed to reduce smoking-related premature deaths.

Keywords

cigarette smoking; mortality; CVD; cancer; all-cause; American Indians; Strong Heart Study

Introduction

Cigarette smoking is the leading preventable cause of death worldwide [1]. It causes more than 480,000 deaths each year in the United States, and the annual smoking-related healthcare costs are over \$133 billion [2]. Thus, cigarette smoking poses a significant burden on public health and economics. Compared to persons who never smoked, current smokers have substantially higher risk of premature death, and the risk of death from cigarette smoking continues to increase in women, though the trend in men appeared to be relatively stable since 1980s [3]. Smoking cessation greatly reduces the risk for chronic disorders, e.g., cardiovascular disease (CVD), respiratory disease and cancer as well as premature death [4].

American Indians have the highest proportion of smokers in the nation [5], and thus are at greater risk of suffering from smoking-related diseases and deaths. However, few studies have investigated the impact of cigarette smoking on mortality in this minority group. In a study of American Indians in the Strong Heart Study (SHS) [6], cigarette smoking was significantly associated with fatal and non-fatal CVD events. However, population attributable risk (PAR) and number of deaths associated with cigarette smoking were not examined. The goal of this study is to evaluate the impact of cigarette smoking on CVD, cancer and all-cause mortality, and to estimate PAR and number of deaths associated with cigarette smoking in American Indians. We used data from a large representative sample of American Indians followed for about 20 years in the Strong Heart Study, a well-characterized prospective cohort study of CVD and its risk factors in American Indians.

Materials and Methods

Study Population

The Strong Heart Study (SHS) is a large, community-based prospective survey of CVD and its risk factors in thirteen American Indian tribes residing in central Arizona (AZ), southwestern Oklahoma (OK) and South/North Dakota (DK) [7].

A total of 4,549 tribal members aged 45 to 74 years, representing 62% of the total eligible population in this age group, attended the initial examination between July 1989 and December 1991. The participation rates were 72%, 62% and 55% in AZ, OK and DK, respectively [7]. Tribal members who did not participate were not appreciably different from SHS participants in age, body mass index (BMI), and self-reported history of diabetes [8]. The SHS study design, survey methods, and laboratory methods had been reported previously [7]. The SHS was approved by the Indian Health Service Institutional Review

Boards, Institutional Review Boards of the participating institutions, and the participating tribe. Informed consent was obtained from all participants.

Baseline Data Collection

All study participants received a personal interview and a physical examination. The personal interview used a standard questionnaire and administered by trained study personnel to collect data on demographic characteristics, medical history, and lifestyle risk factors including smoking, alcohol consumption, diet and physical activity. The physical examination included anthropometric and blood pressure measurements, and an examination of the heart and lungs. Fasting blood samples were collected to measure lipids and lipoproteins, insulin, plasma creatinine, plasma fibrinogen, and glycosylated hemoglobin, and a 75-g oral glucose tolerance test (OGTT) was performed as described previously [9]. A urine sample was obtained for urinary albumin and creatinine measurements. Urinary albumin excretion was estimated by the ratio of albumin (mg) to creatinine (g). Plasma creatinine was measured by the Modification of Diet in Renal Disease Study equation to estimate glomerular filtration rate (eGFR) [10]. Details of the SHS laboratory methods were reported previously [7, 11].

Cigarette smoking was classified as current smokers, former smokers and nonsmokers. Current smokers reported smoking 100 or more cigarettes in their lifetime and were currently smoking every day or some days during the month. Former smokers were those who had smoked 100 or more cigarettes but were no longer smoking. Nonsmokers were those who smoked fewer than 100 cigarettes or never smoked in their life time [6]. Alcohol consumption was determined by self-reported history of alcohol intake, the type of alcoholic beverages consumed, frequency of alcohol consumption, and average quantity consumed per day per week. Alcohol intake was converted to drinks: 1 drink of alcohol equals to 355 ml of beer, 118 ml of wine, or 44ml of hard liquor [12]. In this analysis, participants were classified as current drinkers, former drinkers and never drinkers. Current drinkers were those who had consumed any alcohol during the past year, former drinkers had stopped consuming alcohol for 12 months, and never drinkers were those who reported never drinking alcohol in their life time [12]. A questionnaire measuring leisure-time and occupational physical activities over the past year was used to estimate the level of physical activity [13]. This questionnaire was designed specifically for American Indians and has been shown to be valid and reliable [14]. Socioeconomic information including family income, education level, and marital status was collected by standard questionnaires. Hypertension was defined as systolic blood pressure (SBP) ≥ 140 mm Hg or diastolic blood pressure (DBP) ≥ 90 mm Hg, or use of antihypertensive medications. Diabetes was defined using the 1997 American Diabetes Association criteria [15], i.e., fasting plasma glucose ≥ 126 mg/dL (7.0 mmol/L) or use of an oral hypoglycemic agent or insulin. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters (kg/m^2). Body weight was defined as normal (BMI $<25\text{kg/m}^2$), overweight (BMI of 25 to 30kg/m^2), or obese (BMI $\geq 30\text{kg/m}^2$) according to the NIH guidelines [15].

Mortality Data Collection

From 1989 through the end of 2008, the SHS had conducted annual morbidity and mortality surveillance of the original SHS cohort to ascertain information on disease status and vital statistics. Deaths among the original SHS cohort between baseline examination and December 31, 2008 were identified through tribal and Indian Health Service hospital records and by direct contact of study participants or their families. The cause of death was determined by the physician members of the Mortality Review Committee using medical records, autopsy reports, and informant interview [16]. A death was classified as a cardiovascular death if the participant died of one of the following reasons: fatal myocardial infarction, sudden death due to coronary heart disease, other fatal coronary heart disease, fatal stroke, fatal congestive heart failure, and other fatal cardiovascular disease [16]. Cancer death was defined by all death due to malignant neoplasm. All materials were reviewed independently by physician members of the SHS Mortality Review Committee to confirm the cause of death. Details of the methods to identify deaths and their causes in the SHS had been described previously [16]. Mortality data used in this study included deaths from CVD, cancer and any cause occurring in the follow-up period from baseline examination through December 31, 2008. The completion rate for the follow-up of mortality was 99.8%.

Statistical Analysis

Eight participants (5 men, 3 women) were excluded from the current analysis due to missing information on cigarette smoking. Time to death (in years) and person-years of follow-up were calculated from the date of baseline examination to the date of death or last follow-up. Age-adjusted death rates (ADRs) were calculated using the direct method and the U.S. 2000 standard population [17, 18]. The 95% confidence intervals (CIs) of the mortality rates were calculated using the method described by Curtin and Klein [19]. Relative risks of deaths from CVD, cancer or all-cause for current smokers were calculated using nonsmokers as the reference category. Similar methods were used for former smokers versus nonsmokers.

In order to estimate relative risk of deaths associated with cigarette smoking, we constructed a series of Cox proportional hazards models, adjusting for multiple risk factors including baseline age, study site (AZ, OK, DK), the interaction between study site and current smoking, educational level (less than high school or higher), alcohol consumption (current, former, never), level of physical activity (continuous), BMI, low density lipoprotein cholesterol (LDL), high density lipoprotein cholesterol (HDL), renal function as assessed by eGFR (continuous) and hypertension or diabetes. Since previous study [16] indicated that mortality rates and prevalence of current smoking varied among the three study sites, an interaction term between current smoking and study site was also included in the statistical model.

Because smoking prevalence varies according to sex, age groups (45–54, 55–64 and 65–74 years), and study site (AZ, OK and DK), we also conducted subgroup analyses using estimates for each subgroup to examine how smoking-attributable mortality changes by these variables. Multivariate-adjusted relative risk (RR) was obtained for each subgroup with appropriate adjustments of covariates. PAR for each subgroup was then calculated

using the following equation: $PAR = Pd \times \left(\frac{RR - 1}{RR} \right)$, where RR represents the multivariable-adjusted relative risk of death associated with current smoking (compared to nonsmokers), and Pd denotes the proportion of death (CVD, cancer or any cause) exposed to cigarette smoking [20]. Absolute number of deaths attributable to cigarette smoking in each subgroup was calculated by multiplying the subgroup-specific PAR derived from the present study and number of death in the corresponding subgroup. In this study, we report two-sided P values without adjustment for multiple testing. All analyses were conducted using SAS version 9.3 (SAS Institute Inc., Cary, NC).

Results

Prevalence of current cigarette smoking at baseline was 40.5% in men and 29.3% in women. Participants from DK had the highest prevalence of current smoking (48.6%), followed by OK (33.7%) and AZ (19.0%). Prevalence of current smoking in tribal members aged 45–54, 55–64 and 65–74 years was 39.2%, 31.5% and 24.9%, respectively. Age-adjusted death rates for CVD, cancer and all-cause combined were higher in men than in women.

Baseline characteristics of study participants according to smoking status are shown in Table 1. Overall, smokers were younger, had smaller BMI, and physically active than nonsmokers in both men and women. Current smokers were also less likely to have diabetes and hypertension than their counterparts in both sexes. In addition, male current smokers had lower education level and lower family income than male nonsmokers, whereas female current smokers tended to have higher education level than female nonsmokers. Family income of female current smokers was slightly lower than female nonsmokers.

Current Smoking and CVD Mortality

A total of 643 CVD deaths (307 men, 336 women) were confirmed during the follow-up. CVD death accounted for 32.8% and 30.7% of the total deaths in men and women, respectively. Current smoking significantly increases CVD mortality in women (HR 2.2, [1.1–4.4]), but not men (HR 1.2, [0.6–2.4]). PAR associated with current smoking in women was 14.9%. Subgroup analyses according to age groups showed that current smoking was significantly associated with excess CVD mortality in women younger than 55 years (HR 8.9, [2.2–35.5]), but not in those older than 55 years. PAR was 28.4% in women <55 years old. No significant association was observed between current smoking and CVD mortality in center-specific analysis.

Current Smoking and Cancer Mortality

A total of 351 cancer deaths (154 men, 197 women) were confirmed during the follow-up. Cancer deaths accounted for 16.5% and 18.0% of total deaths in men and women, respectively. Current smoking significantly increases cancer mortality in both men (HR 5.0 [1.9–13.4]) and women (HR 3.9, [1.6–9.7]), with PAR of 41.0% and 24.9%, respectively. Analyses stratified by age groups showed that current smoking significantly increases cancer mortality in men aged 55–74 and women aged 55–64 years, but not participants in other age groups. Site-specific analyses demonstrated that current smoking was associated with a

substantial increase in cancer death among participants from DK in both men (HR 3.5, [1.2–10.3]) and women (HR 2.7, [1.3–5.4]). However, cigarette smoking was not associated with an increased risk of cancer deaths in either men or women from AZ and OK.

Current Smoking and All-cause Mortality

During the follow-up period (total 64,082 person-years), a total of 2,029 tribal members (936 men, 1,093 women) died. Current smoking significantly increases all-cause mortality in both men (HR, 1.8 [1.2–2.6]) and women (HR, 1.6 [1.1–2.4]). PAR associated with current smoking was 18.4% and 10.9% in men and women, respectively. Age-stratified analyses indicated that current smoking significantly increases all-cause mortality in men younger than 65 years (HR 2.1, [1.03–4.2] for men aged 45–54 years, HR 2.3, [1.2–4.6] for men aged 55–64 years). PARs associated with current smoking were 24.2% and 22.7%, respectively, for the two groups. No significant association was observed between smoking and all-cause mortality among men > 65 years and women in any age group. Site-specific analyses revealed a significant association of current smoking with all-cause mortality in men from OK (HR 1.6, [1.1–2.5]) and women from DK (HR 1.5, [1.1–2.0]). PAR associated with smoking was 15.0% in men from OK and 15.8% in women from DK. No association was observed between current smoking and all-cause mortality in DK men, OK women and AZ participants (neither men nor women).

Multivariate-adjusted relative risks along with their 95% CIs as well as PAR associated with current smoking for CVD, cancer and all-cause mortality stratified by sex are shown in Table 2. Age- and site-specific results are shown in Tables 3 and 4, respectively. Additional adjustments for smoking duration, pack-years or menopausal status for women have no appreciable effect on our results. We did not observe an association of former smoking with excess deaths in CVD, cancer or all-cause combined.

Discussion

This is the first large, community-based prospective study to investigate the influence of cigarette smoking on mortality in a representative sample of American Indian adults aged 45–74 years. It shows that smoking prevalence in American Indian men (40.5%) and women (29.3%) in the SHS is much higher than that in the US general population (20.5% among males and 15.8% among females) [5]. Cigarette smoking was significantly associated with excess deaths in CVD (in women only), cancer and all-cause combined independent of multiple established risk factors. We also revealed a high proportion of smoking attributable risk, indicating that smoking cessation may eliminate or reduce a substantial fraction of premature deaths in this minority population.

The observed association between current smoking and excess mortality differs according to sex, age group and study site. First, in consistent with previous studies in other ethnic groups, younger American Indian adults are more likely to be current smokers than their older counterparts. As such, current smoking was significantly associated with an increased risk of CVD mortality among women younger than 55 years but not those older than 55 years. This also corroborates previous finding that female smokers are at higher risk of heart disease than male smokers [21, 22]. The observed association in younger women is unlikely

to be confounded by menopausal status because additional adjustment for menopausal status did not change our results. Second, we observed a significant association of current smoking with increased cancer mortality among participants aged 55 years and older, and the association appears to be more pronounced in men than in women. While this is in agreement with previous studies demonstrating that men in general have higher risk for cancer than women [23, 24], it may be inconsistent with previous reports showing that women are more susceptible to lung cancer than men [25]. Although the biological mechanism behind the observed sex differences in cancer mortality awaits further investigation, it is plausible to hypothesize that physiological difference or perhaps the different pattern of cigarette smoking between the two sexes may play a role [22]. Third, smoking rates in American Indians vary considerably from one tribe to another [26–28]. In our study population, participants from DK have the highest prevalence of current smokers (48.6%), followed by OK (33.7%) and AZ (19.0%). Consistent with this, relative risk and smoking-attributable mortality exhibit a similar pattern with greater in DK, less in OK and the least in AZ. In addition, culture plays an important role in tobacco use in American Indian communities [29], where traditional tobacco is often used for religious, ceremonial, or medical purposes [30]. Smoking patterns may also vary greatly among different tribal groups [26, 30, 31].

Moreover, American Indian lands are sovereign nations and are not subject to state laws prohibiting the sale of tobacco products to minors. As a result, American Indians have access to tobacco products at a very young age. These tribe-specific characteristics should be taken into account when designing and implementing smoking cessation programs or culturally specific interventions in American Indian communities [32, 33].

Our study has a number of limitations. First, information on cigarette smoking was collected by questionnaires instead of measuring biochemical markers for tobacco metabolism, which was believed to be more accurate. However, this should not bias our findings greatly because smoking information was collected during an era when smoking was accepted (religion), and a bias to deny or minimize smoking would be unlikely. Second, in this study, we only report the association of cigarette smoking with mortality, but many other causes e.g., respiratory diseases, liver disease, kidney disease, injuries, etc., are also important causes for premature death among individuals aged 45–74 years. Impact of these factors on risk of death should also be investigated in future studies. Third, we were unable to assess the potential impact of passive smoking or smoking cessation on mortality due to lack of detailed information in our study population. In addition, being a former smoker appears not to appreciably increase the risk of death in our study population. While this is in support of previous studies showing that smoking cessation substantially reduces the risk of death [34–36], the precise relationship between past smoking and mortality in our study population needs further analysis. Fourth, all our study participants are American Indian adults. It is unclear whether our findings could be generalized to other ethnic groups or younger populations. In addition, given the high prevalence of obesity and diabetes in our study population, generalization to other populations with different risk profiles is also unknown. However, our results are unlikely to be confounded by obesity and diabetes because we adjusted for these two chronic disorders as well as other comorbid conditions in all statistical analyses. Finally, although we were able to control many of the known risk

factors, residual confounding cannot be entirely excluded, because smokers and nonsmokers may still differ with respect to many other unmeasured or unknown variables that contribute to risk of premature death.

Our study has several strengths. First, in the SHS, data on baseline cigarette smoking and other potential confounding factors (e.g., lifestyle risk factors) were carefully collected with the use of stringent quality-control procedures [7]. In addition, our analyses adjusted for a comprehensive list of potential confounders including renal function for which most previous smoking-related studies did not control. The adjustment of renal function is important because kidney disease is a key contributor to mortality [37], and American Indians experience disproportionately high rates of kidney diseases [38, 39]. Second, compared to previous similar studies, our follow-up rate is high and all deaths were confirmed using standardized and stringent protocols. Third, unlike most previous studies which collected mortality data during the 1990s, information on mortality in our study was conducted through end of 2008, which reflects the patterns of health care and disease burden through current. Therefore, our results should accurately reflect disease burden, in particular CVD and cancer, in this minority group. Finally, the SHS employs highly standardized clinical and laboratory protocols in data collection, and has a long period of follow-up, all of which assure the accuracy of our findings.

In conclusion, current cigarette smoking significantly and independently increases CVD (in women), cancer and all-cause mortality among American Indian adults participating in the SHS. Continued strengthening or initiation of culturally specific smoking cessation programs or interventions is urgently needed to reduce smoking-related deaths in this ethnically important but traditionally understudied minority population in which the prevalence of smoking is extremely high.

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Table 1
Baseline Characteristics of Study Participants According to Smoking Status (SHS, 1989–1991)

Variable	Men (N=1841)			Women (N=2700)		
	Never	Former	Current	Never	Former	Current
N	335	761	745	1134	774	792
Age (years)	56.3±8.2	56.5±8.4	55.0±7.5	57.9±8.1	56.6±8.1	54.9±7.7
Education (high school) (%)	65.4	73.1	78.5	77.2	70.9	71.6
Current drinker (%)	48.7	45.5	68.6	24.0	30.7	44.6
Physical activity	19.6±20.4	19.8±20.4	21.9±20.8	12.1±14.7	14.3±16.0	16.7±16.7
Body mass index (kg/m ²)	30.5±6.3	30.8±6.0	28.6±5.2	31.9±6.6	32.6±6.3	30.0±6.2
SBP (mm Hg)	130.6±18.1	130.5±17.9	125.2±17.8	130.5±20.9	127.9±20.2	122.6±20.0
DBP (mm Hg)	80.7±9.3	80.5±9.9	77.8±10.6	75.7±9.5	75.6±9.5	73.2±9.9
LDL (mmol/L)	3.0±0.8	3.0±0.9	3.1±0.8	2.9±0.9	3.0±0.9	3.1±0.9
HDL (mmol/L)	1.1±0.3	1.1±0.3	1.1±0.4	1.2±0.3	1.2±0.3	1.2±0.3
eGFR (ml/min/1.73m ²)	84.8±19.1	85.4±20.8	89.0±18.5	78.6±22.4	78.1±22.5	80.3±29.9
Total triglyceride (mmol/L)	1.7±1.4	1.8±1.8	1.7±2.6	1.6±1.1	1.7±1.5	1.7±1.3
Prevalence of Obesity (%)	43.4	49.9	37.7	56.5	64.6	45.0
Hypertension (%)	45.3	50.0	34.5	47.3	47.3	28.9
Diabetes (%)	34.1	37.2	24.4	44.7	43.5	28.6
Hypertension treatment (%)	24.2	29.0	15.8	27.5	27.4	17.1
Diabetes treatment (%)	28.7	30.4	18.5	37.0	37.6	23.7
ADR (95% CI)						
CVD	3.1 (0.5–5.8)	5.3 (1.8–8.8)	5.5 (2.0–8.9)	4.0 (1.6–6.5)	2.6 (1.8–8.8)	2.4 (0.6–4.3)
Cancer	0.9 (–0.5–2.2)	2.5 (0.2–4.9)	3.7 (0.8–6.5)	2.0 (0.3–3.7)	1.7 (0.1–3.3)	1.8 (0.2–3.6)
All-cause	7.8 (3.7–12.0)	17.1 (10.9–23.2)	16.9 (10.9–23.0)	12.4 (8.2–16.6)	8.6 (5.1–12.1)	8.4 (4.9–11.8)
Number of death						
CVD	67	114	126	145	99	92
Cancer	19	56	79	71	60	66
All-cause	172	376	388	453	321	319

Abbreviations: SBP, systolic blood pressure; DBP, diastolic blood pressure; LDL, low density lipoprotein cholesterol; HDL, high density lipoprotein cholesterol; eGFR, estimated glomerular filtration rate; ADR, age-adjusted death rate per 1000 person-year.

Table 2

Sex-specific Association of Current Smoking, as Compared to Nonsmoking, with All-cause, CVD and Cancer Mortality in American Indians in the SHS, 1989–2008*

Variable	Men (N=1841)	Women (N=2700)
Person-year of follow-up	24538.4	39543.6
Prevalence of current smoking (%)	40.5	29.3
CVD mortality		
Number of death	307	336
ADR (95% CI)	13.9 (8.4, 19.5)	9.1 (5.5, 12.7)
HR (95% CI)	1.2 (0.6, 2.4)	2.2 (1.1, 4.4)
PAR (%)	–	14.9
# death attributed to current smoking	–	50
Cancer mortality		
Number of death	154	197
ADR per 1000 person-year (95% CI)	7.0 (3.1, 11.0)	5.4 (2.6, 8.3)
HR (95% CI)	5.0 (1.9, 13.4)	3.9 (1.6, 9.7)
PAR (%)	41.0	24.9
# death attributed to current smoking	63	49
All-cause mortality		
Number of death	936	1093
ADR per 1000 person-year (95% CI)	41.8 (32.4, 51.2)	29.3 (22.9, 35.8)
HR (95% CI)	1.8 (1.2, 2.6)	1.6 (1.1, 2.4)
PAR (%)	18.4	10.9
# death attributed to current smoking	173	120

Abbreviations: ADR, age-adjusted death rate per 1000 person-year; HR, hazard ratio; CI, confidence interval; PAR, population attributable risk.

* Adjusted for age, study site, current smoking × study site, educational level, alcohol consumption, physical activity, BMI, LDL, HDL, eGFR, status or hypertension or diabetes at baseline.

Table 3

Sex- and Age-specific Association of Current Smoking, as Compared to Nonsmoking, with All-cause, CVD and Cancer Mortality in American Indians in the SHS, 1989–2008*

Variable	Men (N=1841)			Women (N=2700)		
	45–54	55–64	65–74	45–54	55–64	65–74
Number of participants	926	585	330	1213	941	546
Person-year of follow-up	13336	7694	3508	19389	13516	6639
Prevalence of current smoking (%)	43.8	39.3	33.0	35.7	26.6	20.0
CVD mortality						
Number of death	107	112	88	100	120	116
HR (95% CI)	2.2 (0.6, 7.9)	0.9 (0.3, 2.6)	1.3 (0.3, 5.4)	8.9 (2.2, 35.5)	1.4 (0.4, 4.7)	0.9 (0.3, 3.1)
PAR (%)	–	–	–	28.4	–	–
# death attributed to smoking	–	–	–	28	–	–
Cancer mortality						
Number of death	42	68	44	56	65	76
HR (95% CI)	1.4 (0.2, 8.9)	7.4 (1.6, 34.5)	20.2 (2.8, 146.8)	2.1 (0.5, 8.8)	14.3 (2.1, 98.2)	2.3 (0.4–14.1)
PAR (%)	–	39.4	54.0	–	30.1	–
# death attributed to smoking	–	27	24	–	20	–
All-cause mortality						
Number of death	364	321	251	333	407	353
HR (95% CI)	2.1 (1.03, 4.2)	2.3 (1.2, 4.6)	1.6 (0.7, 3.5)	1.9 (0.97, 3.6)	1.4 (0.7, 2.8)	1.4 (0.7, 3.0)
PAR (%)	24.2	22.7	–	–	–	–
# death attributed to smoking	88	73	–	–	–	–

Abbreviations: HR, hazard ratio; CI, confidence interval; PAR, population attributable risk.

* Adjusted for age, study site, current smoking × study site, educational level, alcohol consumption, physical activity, BMI, LDL, HDL, eGFR, status of hypertension or diabetes at baseline.

Sex- and Site-specific Association of Current Smoking, as Compared to Nonsmoking, with All-cause, CVD, and Cancer Mortality in American Indians in the SHS, 1989–2008*

Table 4

Variable	Men (N=1841)			Women (N=2700)		
	AZ	OK	DK	AZ	OK	DK
Number of participants	543	642	656	952	884	864
Person-year of follow-up	6580	9070	8890	13429	13726	12388
Prevalence of current smoking (%)	29.7	36.8	53.1	12.9	31.5	45.3
CVD mortality						
Number of death	91	96	120	144	77	115
HR (95% CI)	0.7 (0.4, 1.4)	1.4 (0.7, 2.6)	1.0 (0.6, 1.8)	0.8 (0.4, 1.7)	1.6 (0.9, 3.1)	1.6 (0.95, 2.6)
PAR (%)	–	–	–	–	–	–
# death attributed to smoking	–	–	–	–	–	–
Cancer mortality						
Number of death	45	39	70	59	60	78
HR (95% CI)	1.1 (0.4, 3.2)	2.2 (0.8, 6.1)	3.5 (1.2, 10.3)	1.5 (0.6, 3.7)	1.2 (0.6, 2.4)	2.7 (1.3, 5.4)
PAR (%)	–	–	46.9	–	–	36.3
# death attributed to smoking	–	–	33	–	–	28
All-cause mortality						
Number of death	336	260	340	445	269	379
HR (95% CI)	0.7 (0.5, 1.1)	1.6 (1.1, 2.5)	1.2 (0.9, 1.8)	1.4 (0.98, 2.0)	1.4 (0.98, 1.9)	1.5 (1.1, 2.0)
PAR (%)	–	15	–	–	–	15.8
# death attributed to smoking	–	39	–	–	–	60

Abbreviations: HR, hazard ratio; CI, confidence interval; PAR, population attributable risk.

* Adjusted for age, educational level, alcohol consumption, physical activity, BMI, LDL, HDL, eGFR, status of hypertension or diabetes at baseline.