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Prevalence of Smoking and its Relationship with Carotid Atherosclerosis in Alaskan Eskimos of the Norton Sound Region: The GOCADAN Study

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Abstract

Since 2000, the Genetics of Coronary Artery Disease in Alaska Natives (GOCADAN) study has been collecting information on cardiovascular disease (CVD) and its risk factors from 1,214 Alaska Natives of the Norton Sound region, a population with increasing rates of heart disease and stroke. Because smoking was reported in a large proportion of the participants, this analysis was undertaken to evaluate smoking patterns and their relation to other risk factors and to CVD. The relationships among smoking habits and demographic factors, body mass index, plasma fibrinogen, prevalent hypertension, and carotid plaque were evaluated. Eighty percent of participants had smoked 100+ cigarettes in their lifetime. Fifty-seven percent of women and 63% of men ($p = 0.12$) were current smokers: one in four smokers had quit. Current smokers (OR 2.1; 95% CI 1.1–3.8) and those who had quit < 5 years ago (OR 1.6; 95% CI 1.1–2.2) were more likely than non-smokers to have carotid plaque. Pack-years smoked also were correlated with carotid plaque. The high prevalence of smoking and low rates of cessation in this population demonstrate an urgent need for smoking prevention and cessation programs among Alaskan Eskimos of the Norton Sound region and other Alaska Native groups.

Although Alaska Natives have long been thought to have relatively low levels of cardiovascular disease (CVD), their CVD mortality rates rose between 1979 and 1998, while CVD mortality rates in U.S. whites and blacks fell (Lanier, Ehram, & Sardidge, 2002; McLaughlin et al, 2004). Studies have suggested unusually high prevalences of diabetes, hypertension, obesity, and dyslipidemia in Alaska Natives (Ebbesson, Kennish, Ebbesson,

Go, & Yeh, 1998; Ebbesson, Schraer, Nobmann, & Ebbesson, 1996; Ebbesson et al, 1998; Nobmann et al., 1998; Risica, Ebbesson, & Schraer, 2000; Risica, Schraer, Ebbesson, Nobmann, & Caballero, 2000; Schraer et al., 1996; Schraer et al., 1998; Schraer et al., 1999); therefore, it is important to ascertain their levels of exposure to other CVD risk factors.

Smoking and exposure to second-hand tobacco smoke are known risk factors for CVD (Doll, Peto, Wheatley, Gray, & Sutherland, 1994; Ockene & Miller, 1997). Previous studies of Alaskan Eskimos, Aleuts, and American Indians living in Alaska have suggested a high prevalence of smoking in Alaska Natives. A 2002 survey found that 40–44% of Alaska Natives smoked cigarettes, compared with 23–26% of non-native Alaskans (Peterson, Fenaughty, & Eberhart-Phillips, 2004). In 1996, Alaska Natives accounted for 23% of smoking-related deaths in the state, although they comprised only 16.5% of Alaska's population (Alaska Department of Health and Social Services, 1996). Thus, smoking may be contributing to the increasing CVD rates in this population.

The Genetics of Coronary Artery Disease in Alaska Natives (GOCADAN) Study was initiated in 2000 to examine whether interactions between a unique but changing diet and lifestyle, traditional CVD risk factors, and genetic factors could explain the high rate of heart disease in this population. The objectives of this analysis were to define smoking patterns in this population-based sample of Eskimos and assess the correlation of smoking with other CVD risk factors and with carotid atherosclerosis.

METHODS

Study population

A total of 1,214 predominantly Inupiat Eskimos (537 men and 677 women) 18 years old from nine villages (including the town of Nome) in the Norton Sound Region of Alaska were examined in 2000–2004 for cardiovascular disease (CVD) and associated risk factors as part of the Genetics of Coronary Artery Disease in Alaska Natives (GOCADAN) study (Howard et al., 2005). Recruitment was conducted by family (i.e., study staff went to each residence and recorded family relationships to be used in the genetic analyses for all those age 18. All residents over age 18 were invited to participate in the exam.) In seven of the nine villages, an average of 82.6% of all residents > 18 years participated. Screenings were terminated early in the remaining village because the villagers had left for fishing season and in the town of Nome when the study recruitment goal was met.

After receiving permission from each village council, all households in the eight villages and Nome were contacted. Individuals who consented to participate (62% of the eligible population) completed an interviewer-administered survey of personal and medical history, as well as a dietary questionnaire. Blood samples were collected for measurement of blood sugar, lipids, and other laboratory measurements. Participants underwent a physical examination, including measures of diabetes and hypertension and a carotid ultrasound examination to measure risk factors for atherosclerosis. In addition, anthropometric and demographic data were collected. A detailed description of the study methods has been published (Howard et al., 2005).

Data collection

Data collected on tobacco use were derived from an interviewer-administered questionnaire developed by the Strong Heart Study (Welty TK, Lee ET, Yeh J, et al., 1995) for use in Native communities. Participants were asked the following questions:

- “During your lifetime have you smoked 100 cigarettes or more total?”
- “Do you smoke cigarettes now?”
- “Would you like to stop or reduce your smoking?”
- “Have you quit smoking permanently?”
- “How old were you when you first started smoking fairly regularly?”
- “What year did you quit smoking?”
- “On average, how many cigarettes do/did you usually smoke per day?”

Exhaled CO level, a biochemical validation of self-reported non-smoking status, was measured using a Vitalograph EC50 CO Monitor. Number and duration of past attempts at quitting were not assessed.

Sitting blood pressure was measured three times, following a 5-minute rest, on the right brachial artery using a Baum mercury sphygmomanometer (W.A. Baum, Copiague, NY), and the average of the second and third measurements was used as the blood pressure measure. Height was measured to the nearest quarter inch using a wall-mounted stadiometer, and weight was measured to the nearest tenth of a pound. Body mass index (BMI) rounded to the nearest 0.1 kg/m² was calculated, using the formula and metric conversion:

$$\text{BMI} = \text{weight (lb)} / \text{height}^2 \text{ (in)} * 704.5 \text{ kg m}^2 / \text{lb in}^2$$

Obesity was defined as BMI ≥ 30 kg/m², while participants with 25 ≤ BMI < 30 were considered overweight. Using the JNC VI definition of hypertension (Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure, 1997), participants were considered to have prevalent hypertension if they reported taking anti-hypertensive medication or had systolic blood pressure ≥ 140 mmHg or a diastolic blood pressure ≥ 90 mmHg.

A random urine sample was collected and blood taken by venipuncture at fasting and 2 hours after consuming a 75-g glucose load (Glutol, Paddock Laboratory, Inc., Minneapolis, MN). Participants were excluded from the glucose tolerance test if they were a) insulin-requiring diabetics, b) used oral agents, with records indicating two random blood glucose values > 250 mg/dl, and c) had fasting glucose of > 225 mg/dl (Howard et al., 2005). Diabetes was determined by self-report and a measure of fasting glucose (Accu-Chek Advantage). Participants were considered diabetic if they reported previous or current use of either insulin or oral diabetes medication, if they recorded a fasting glucose > 126 mg/dl at the exam, or if they recorded a 2-hour glucose level > 200 mg/dl after ingesting a 75 g oral glucose load.

A quantitative food frequency questionnaire (FFQ), which was adapted for use in the Norton Sound Region, was administered and used to calculate average daily caloric intake (Nobmann et al., 2005). The FFQ, which measured consumption in the previous year, was based on an FFQ previously developed for use in the region (Nobmann et al., 2005). Results from the original FFQ were validated with 24-hour recalls in one village ($r = 0.52$, $p < 0.001$ for saturated fatty acid, 0.39 $p = 0.002$ polyunsaturated fats, 0.37 $p = 0.004$ monounsaturated fats, 0.31 $p = 0.015$ total fats, 0.22 $p = 0.091$ protein and 0.19 $p = 0.143$ carbohydrate). The original FFQ was modified to include foods from the villages being surveyed and more details about specific fats and food preparation. A total of 97 local and store-bought foods were included. Although this may be a smaller number of foods than are present in other FFQs, it includes the key foods available in small village stores and the major traditional foods. Although no further validation was conducted, the changes help to improve the relevance of the FFQ and minimize respondent burden. Quality assurance procedures were in place for data collection, data entry, and analysis (Nobmann et al., 2005). Dietary data were treated as missing for 65 participants who reported implausible daily calorie intakes (< 500 kcal/day, > 8000 kcal/day).

Activity levels were measured using a Modifiable Activity Questionnaire, adapted from the one used in the Strong Heart Study (Kriska et al., 1990), that included 15 non-occupational activities specific to the GOCADAN population. The interviewer-administered questionnaire was used to assess activities over the past year. For each activity, the participant was asked how many times it was done per day, week, month, or year and the starting and ending month of the activity. From these data, the number of times each activity was done per week averaged over a year was calculated. This value was then multiplied by the metabolic equivalent (MET) value for each activity to get a MET times per week value. The sum of MET times per week for all activities was calculated for each participant ($n = 1,071$) and used as a measure of physical activity. Because the variable of total METs was skewed, a variable representing the gender-specific quartile of total METS was used for analyses of relationships between physical activity and smoking behavior, with quartile 1 representing the lowest level of physical activity. There were 43 participants who did not provide complete responses to the activity questionnaire, and 30 additional respondents whose weekly activity totals were < 1.0 METS or > 300 METS were removed as outliers who were likely to have provided inaccurate data. Those with missing or removed activity data did not differ significantly from the remainder of participants with respect to any of the other variables in our study.

The presence of carotid atherosclerotic plaque at eight carotid locations (right and left common carotid, bulb, and internal and external carotid arteries) was assessed by ultrasound using an established protocol (Roman et al., 1992; Roman, Pickering, Schwartz, Pini, & Devereux, 1995). Two-dimensional (B-Mode), two-dimensional guided M-mode images, and Doppler recordings were used to identify lesions and grade each site as having either no discrete atherosclerosis, non-obstructive atherosclerosis (discrete lesions > 1.5 times the thickness of adjacent arterial wall with $< 50\%$ luminal narrowing), significant stenosis ($50\text{--}74\%$ luminal narrowing), severe stenosis ($> 75\%$ luminal narrowing), or undetermined status. For this analysis, plaque was assessed as present if any level of obstruction was found

at one of the sites and absent if all eight sites showed no obstruction. Participants with undetermined status at one or more sites and no plaque elsewhere were excluded (n = 11).

Statistical analyses

Prevalences and smoking patterns were described by age, gender, education, household income, and quartile of physical activity to identify subgroups of the GOCADAN population with higher rates of cigarette smoking. Each of the demographic factors above was evaluated for its association with smoking habits. Univariate logistic regression models (SAS PROC LOGISTIC V 9.1) were constructed with each demographic variable as an independent variable and one of three binomial variables for smoking status as the dependent variable. The three binary variables for smoking status compared participants who never smoked (n = 234; 19%) to participants who ever smoked (n = 974; 81%), to participants who were current smokers at the time of the survey (n = 721; 60%), and to participants who had quit smoking (n = 253; 21%).

For each binary dependent variable, a set of three multivariate regressions was performed, including a full model with village and all five demographic covariates as independent predictors of smoking and forward and stepwise models with thresholds of $p = 0.01$ for entry/retention, which have been recommended for descriptive models (SAS Institute, 1995). The stepwise model was used to assess whether the significance of a given variable changes as the context (the other variables in the model change) changes. Had the forward and stepwise models differed, the AIC statistics would have been compared for the competing models to compare model fit. Additionally, the relationship between the variables could have been removed, and those remaining in the stepwise models could have been assessed to see if there was a biologically plausible explanation for why the change in model context resulted in the removal of a covariate(s). However, no such differences in the best fitting forward and stepwise models were observed.

We compared current smokers to ex-smokers to examine whether any of the demographic factors were predictors of quitting, using the same modeling procedure outlined above. Among all smokers, we used univariate general linear models to test whether each independent demographic factor was associated with number of pack-years and daily cigarettes smoked, as well as the age when smoking began. A full model, including village and all five demographic factors as covariates (SAS PROC GLM V 9.1), and forward and stepwise regressions (SAS PROC STEPWISE V 9.1) were also performed.

We also tested the hypothesis that after adjusting for demographic and other risk factors, smoking habits would be associated with the presence of prevalent hypertension (as defined above), and with carotid plaque as binomial outcomes, as well as with BMI, and plasma fibrinogen as continuous variables. One set of four univariate models included pack-years smoked as a continuous independent variable, and each of the four phenotypes above as a dependent variable. A second set of four models included a pair of binary dummy variables for current smokers and ex-smokers as the only independent variables. All of these analyses were then adjusted in full multivariate models for village, age, gender, education, household income, and physical activity. In addition, the relationship between smoking and BMI was adjusted for diabetes; the relation between smoking and hypertension was adjusted for

diabetes and BMI; and the relationship between smoking and plaque was adjusted for diabetes, BMI, and prevalent hypertension as defined above. Forward and stepwise models were also used, forcing the smoking variables to be included in each model. The relationship between smoking and binomial phenotypes was evaluated using multiple logistic regression, while relationships to continuous phenotypes were measured using general linear regression models. All analyses were carried out using SAS version 9.1. Two-tailed p values < 0.05 were considered statistically significant.

The institutional review boards of the MedStar Research Institute of Washington, DC; the Southwest Foundation for Biomedical Research; the Cornell University School of Medicine; and the Scientific Advisory Board of the Norton Sound Health Corporation approved the study protocol. All participants signed a written informed consent form.

RESULTS

In seven villages, 82% of eligible individuals participated in the study. In one village and in Nome, recruitment was stopped early because the study recruitment goal of 1,200 participants had been met (total $n = 1,214$). Six participants provided no information on their smoking habits, leaving 1,208 GOCADAN participants for analysis, including 25 non-Native family members. Two-thirds of women and more than half of men surveyed were overweight or obese, and 20% were hypertensive (Table 1). Approximately one-third showed evidence of carotid plaque.

Prevalence and amount of cigarette smoking

Four out of five participants reported having smoked more than 100 cigarettes in their lifetime (Table 2). Among those who ever smoked, approximately one quarter had quit at the time of the interview, leaving 60% of the population who were current smokers. In the various villages and the town of Nome, the proportion of those who ever smoked ranged from 73–92%, while the proportion of current smokers varied from 50–88%. A total of 7% of participants ($n = 79$) used chewing tobacco. Half of those who chewed tobacco also smoked. Thus, 63% of participants currently used some form of tobacco. Participants who smoked used an average of 11.4 cigarettes per day over 23 years, for an average of 14.8 pack-years.

On average, participants began smoking between the ages of 16 and 17 (Table 2), although by age 12, 11% of smokers had already started. By age 18, 81% of ever-smokers had started.

Most smokers (81%) stated that they would like to quit or reduce their level of smoking (data not shown). Smokers under age 45 were more interested in quitting than older smokers (86 vs. 73%, $p < 0.0001$). However, only 1 in 4 smokers in the GOCADAN study has been able to quit.

Correlates of smoking behavior

The conclusions about which demographics factors were significantly associated with smoking behaviors did not vary in the full, forward, and stepwise multivariate models. As a

result, data presented are based on the full multivariate models, where the effect of each demographic factor is adjusted for the other factors in Table 2.

Gender—Men and women did not differ significantly in the fraction who ever smoked (83% vs 79%, respectively; $p = 0.16$ adjusted for the other factors in Table 2) or in the percentage who currently smoked (63% vs 57%; respectively; $p = 0.12$ adjusted for the other factors in Table 2). The men smoked significantly more cigarettes/day than the women (Table 2) and had smoked for a significantly longer period of time (data not shown). As a result, in the GOCADAN population, the average male smoker has been exposed to 17.5 pack-years compared with 12.5 among women who smoke ($p < 0.0001$ adjusted for the other factors in Table 2). Eleven percent of men ($n = 58$) and 3% of women ($n = 21$), reported using chewing tobacco (odds ratio [OR] for male gender = 3.8; 95% confidence interval [CI]: 2.3, 6.3; $p < 0.0001$ adjusted for the other factors in Table 2). The same proportion of male (80%) and female (81%) smokers expressed a desire to quit, but women were somewhat more successful than men in quitting (28% vs. 24%, $p = 0.01$ adjusted for the other factors in Table 2).

Age—Smoking habits differed by age. Relatively similar proportions of people between the ages of 18–65 had smoked regularly during their lifetime (Table 2), while the proportion who currently smoke decreased steadily after age 25. After removing smokers who began smoking after age 25 ($n = 33$) to avoid biasing the age when smoking began in older cohorts, and observed that younger members of the GOCADAN cohort began smoking at earlier ages than their elders (p for trend < 0.0001 , adjusting for the covariates in Table 2), while the older smokers smoke more cigarettes per day (adjusted p for trend < 0.0001) (Table 2).

Education—Of 1,208 respondents, 1,198 (99%) provided information on their education. The likelihood of ever smoking was significantly higher among those with ≤ 12 years of education (age, village, gender, income adjusted OR = 1.9; 95% CI: 1.2, 2.9; $p = 0.006$) compared with participants who had 13+ years of school, as was the likelihood of being a current smoker (OR = 2.1; 95% CI: 1.5, 3.0; $p < 0.0001$). The adjusted odds of quitting smoking among smokers with 13+ years of education were 2.0 (95% CI: 1.1, 3.3; $p = 0.008$) compared with those who had 1–12 years of school. Smokers with > 12 years of education also smoked significantly fewer cigarettes per day and smoked for fewer pack-years than smokers with 1–12 years of school (both $p < 0.02$). The desire to quit and mean years smoked did not vary significantly with education.

Income—Eighty-two percent of participants provided data on total household income, 16% ($n = 188$) did not know their household income, and 2% ($n = 28$) refused to answer the question. Based on the 992 participants who responded, it was evident that as household income increased, the proportion who ever smoked decreased, while the proportion of smokers who had quit increased (both adjusted $p < 0.0001$) (Table 2). Participants with total household incomes below \$35,000 were twice as likely to have ever smoked (age, gender, village adjusted OR 2.0, 95% CI: 1.4, 2.9, $p = 0.0004$), independent of education, and were more likely to be current smokers (OR = 2.5, 95% CI: 1.9, 3.4, $p < 0.0001$) than those with higher household incomes. Although desire to quit did not vary significantly with income,

the adjusted odds of quitting for those with household incomes above \$35,000 were 2.9 higher than for those with lower household incomes (95% CI: 2.0, 4.2; $p < 0.0001$).

Physical activity—No smoking behaviors were significantly related to quartile of physical activity. Although the percentage of those who ever smoked increased with increasing quartile of physical activity, these differences were not significant after adjusting for the other factors in Table 1 (adjusted OR of ever smoking with increase in one quartile of physical activity = 1.1, 95% CI: 0.9, 1.3, $p = 0.25$). Similarly, observed decreases in the age smokers began smoking with increased physical activity were not significant (adjusted $p = 0.88$).

Smoking in relation to other cardiovascular disease risk factors

The conclusions about whether smoking behavior factors were significantly associated with CVD risk factors also did not vary in the full, forward, or stepwise multivariate models. As a result, data presented are based on the full multivariate models, where the effect of smoking is adjusted for the covariates listed in the methods section.

Body Mass Index (BMI)—BMI in this population was significantly, negatively related to current smoking as well as pack-years smoked. Women who were current smokers at baseline had significantly lower BMIs (mean 27.8 kg/m²) than current non-smokers (29.5 kg/m²; adjusted $p = 0.02$), adjusting for diabetes, age, education, income, activity, and village. Men who currently smoked also had lower BMIs than non-smokers (25.4 kg/m² versus 28.5 kg/m² respectively; adjusted $p < 0.0001$). Smokers who quit had a mean BMI that was closer to the mean of never-smokers than current smokers in both men (never smoked: 28.2; ex-smoker: 27.9; current smoker 25.4 kg/m²) and women (never smoked: 29.4; ex-smoker: 28.9; current smoker: 27.8 kg/m²). Despite the fact that smoking is associated with lower BMI, both the male and female smokers consumed significantly more (adjusted $p = 0.002$) calories per day than the non-smokers, adjusting for age, village, and physical activity. These differences remained the same after adjusting dietary intake for weight of the participants.

Fibrinogen—Current smokers had significantly higher plasma fibrinogen (334 mg/dL) than those who did not currently smoke (321 mg/dL) (adjusted $p = 0.05$). Number of pack-years smoked also was strongly correlated with fibrinogen (adjusted $p < 0.0001$), suggesting a dose-response relationship.

Hypertension—Current smokers had a mean systolic blood pressure approximately 5 mmHg lower than non-smokers (95% CI: 2.9, 7.4 mmHg; adjusted $p < 0.0001$). No significant relationship was observed between smoking and diastolic blood pressure. Current non-smokers had a prevalence of hypertension (31%) that was twice that of current smokers (15%). In the univariate model, current smoking appeared to be independently, negatively related to prevalent hypertension (OR = 0.6, 95% CI: 0.4, 0.8 $p = 0.02$), while number of pack-years smoked did not influence hypertension. However, after adjusting for BMI, and the demographic covariates, current smoking was no longer significantly associated with prevalent hypertension (OR = 0.7; 95% CI: 0.5, 1.1). BMI was significantly higher among

both men and women with prevalent hypertension than those without hypertension (men: 27.7 kg/m² vs. 25.4 kg/m²; $p < 0.0001$; women 29.7 kg/m² vs. 27.4 kg/m², $p < 0.0001$).

Carotid plaque—Of 1,131 participants with plaque score assessments, 34% had evident plaque in one or more of eight segments measured in the carotid artery system. The same proportion of current smokers and never-smokers (31%) had prevalent plaque. However, after adjusting for village and the factors in Table 1, current smokers (OR 2.1; 95% CI: 1.1, 3.7; $p = 0.01$) and ex-smokers who quit 5 years ago (OR 1.6; 95% CI: 1.1, 2.2 $p = 0.007$) were more likely than never-smokers to have prevalent plaque. Smokers who quit more than 5 years ago had adjusted odds of carotid plaque similar to those who had never smoked (OR = 1.1; 95% CI: 0.7, 1.9). Table 3 shows significant associations of smoking with plaque in those over age 45 (OR 1.8–4.4). The overall OR, adjusted for age, gender, village, hypertension, BMI, diabetes, and education was 2.1 (1.2–3.7). The number of pack-years smoked also significantly predicted carotid plaque ($p = 0.002$); odds of plaque increased by 2% with each additional pack-year smoked, adjusting for the same covariates listed above.

DISCUSSION

This study presents the first available population-based data on the smoking habits of Alaskan Eskimos. Nearly six in ten people in the Norton Sound region currently smoke, even after observing deaths due to smoking, compared with 22% of the United States as a whole. The average age that smokers in GOCADAN began (16.5 years) was slightly higher than the average of 15.4 years among U.S. whites in general (SAMSHA Office of Applied Studies, 1999), and daily use was lower among GOCADAN participants (11.4 cigarettes/day) than among U.S. white smokers in general (14.9/day) (SAMSHA Office of Applied Studies, 2003). In both the GOCADAN population and the United States in general, men tend to smoke more, and more often, than women. Those who earn less, and those with a high school education or less tend to smoke more, and people between the ages of 18 and 44 are those most likely to be current smokers.

Combining the observation that similar proportions of participants of all age groups have smoked before, with the observation that older smokers were less likely to currently smoke seems to reveal a pattern of older respondents who are more likely than their younger counterparts to have quit smoking. However, these observations are likely to be affected by survival bias, because older participants are more likely to have survived and participated in the study if they never smoked or quit smoking.

More Alaskan Eskimos who smoke (81%) say they would like to quit than U.S. smokers as a whole (70%) (Centers for Disease Control, 2002). However, only one in four Alaskan Eskimo smokers had quit, compared with 49% of people who ever smoked in the United States as a whole (Centers for Disease Control, 2002). In both the United States as a whole and in the GOCADAN participants, ever-smokers over age 65 and those with more education or higher income are the most likely to have quit, while current smokers over age 65 are least interested in quitting.

The data also suggest that smoking is related to increased atherosclerosis: a strong association was seen between smoking and the presence of carotid plaque in older participants (Table 3), and there appeared to be a dose-response relationship implied by the significant increase in age-adjusted odds of plaque associated with the number of pack-years smoked. There were no significant relations in those younger than 45 years, but that may be explained by the lower prevalence of plaque in those age groups.

The high rate of smoking and its association with plaque suggests that successful public health efforts to prevent tobacco smoking may have considerable impact on cardiovascular health in Alaskan Eskimos. GOCADAN participants are currently less likely than smokers in the general U.S. population to have quit smoking. Although a patchwork of initiatives on general health in schools and maternal and child health clinics urge Alaskan Eskimos to stop smoking, more concentrated programs to promote and aid smoking cessation in Alaska appear to be needed. Because 80% of GOCADAN smokers begin before age 18, successful prevention must start early and include ways to motivate adolescents. Wide variation among GOCADAN villages in the rates of both current smoking and cessation suggests there may be local lessons that could be applied in the villages where quitting is less common.

Income does not appear to influence the amount of money GOCADAN participants spend on cigarettes, because daily usage among smokers was similar across categories of income. However, these data cannot answer whether increased taxes in Alaska (\$1.00/pack at the time the study was begun) have reduced the tendency for poorer participants to smoke more that is observed in many other areas of the United States.

The association between smoking and lower BMI has been described in other research (e.g., John, 2006; Chou, 2004), particularly when comparing current smokers to those who have quit (Lahti-Koski et al., 2002; Froom et al., 1998; Rasmussen et al., 2003). In this study, lower BMI among smokers does not appear to be due to lower dietary intake among smokers and is not accounted for by reported activity levels or employment status.

One possible explanation is that cigarette smoking stimulates adipose tissue lipoprotein lipase (Ferrara, Kumar, Nicklas, McCrone, & Goldberg, 2001), which increases fat metabolism. This activity has been shown to stop when smoking ceases, which could account for weight increases after cessation.

A major limitation of these data is their cross-sectional nature, which is likely to lead to a strong survival bias when evaluating the association of smoking with prevalent CVD or comparing habits of young and old. The cross-sectional nature of the data makes it difficult to assess whether GOCADAN participants with a high BMI have avoided or stopped smoking to improve their health, or whether smoking has truly had an effect on lowering BMI. It also is difficult to draw conclusions about differences in smoking habits between age groups, because of survival bias; fewer long-term smokers will survive past age 60, biasing the proportion of smokers in older age groups downward.

In conclusion, Alaskan Eskimos of the Norton Sound have alarmingly high rates of smoking, while only a small proportion of these smokers has been able to quit. Comparing the prevalence of smoking between demographic subgroups of the Alaskan Eskimos of

Norton Sound reveals patterns similar to those seen across the rest of the United States; men smoke more than women, young people smoke more than old, and those with less education and money smoke more often. Across all subgroups, the prevalence of smoking in Norton Sound is significantly higher than across the rest of the United States, and this smoking is strongly correlated with the presence of carotid plaque. These findings demonstrate an urgent need for smoking prevention and cessation programs among Alaskan Eskimos and other Alaska Native groups. These results may be useful as a reference point to assess potential smoking intervention programs in the Norton Sound area of Alaska. This information also will help guide analyses of the relationship between genes, dietary and other risk factors, and CVD outcomes that require incorporation of smoking as a confounder or interaction term.

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REFERENCES

- Alaska Department of Health and Social Services. Epidemiology Bulletin: "Smoking related mortality in Alaska, 1992–94,". 1996 Jan 12.
- Centers for Disease Control. Cigarette Smoking Among Adults - United States, 2000. MMWR. Morbidity and mortality weekly report. 2002; 51:642–645. [PubMed: 12186222]
- Chou S, Chou Y, Grossman M, Saffer H. An economic analysis of adult obesity: results from the behavioral risk factor surveillance system. *Journal of Health Economics*. 2004; 23:565–587. [PubMed: 15120471]
- Doll R, Peto R, Wheatley K, Gray R, Sutherland I. Mortality in relation to smoking: 40 years' observation on male British doctors. *British Medical Journal*. 1994; 309:901–911. [PubMed: 7755693]
- Ebbesson SOE, Kennish J, Ebbesson LOE, Go O, Yeh J. Diabetes is related to fatty acid imbalance in Eskimos. *International Journal of Circumpolar Health*. 1998; 58:108–119.
- Ebbesson SOE, Laston S, Wenger CR, Dyke B, Romenesko T, Swenson M, Fabsitz R, MacCluer JW, Devereux R, Roman M, Robbins D, Howard BV. Recruitment and Community Interactions in the GOCADAN Study. *International Journal of Circumpolar Health*. 2006; 65:55–64. [PubMed: 16544648]
- Ebbesson SOE, Schraer CD, Adler A, Ebbesson L, Mayer AM, Shubnikof EV, Yeh J, Go OT, Robbins DC. Diabetes mellitus and impaired glucose tolerance in three Alaskan Eskimo populations: The Alaska-Siberia Project. *Diabetes Care*. 1998; 21:563–569. [PubMed: 9571343]
- Ebbesson SOE, Schraer DC, Nobmann ED, Ebbesson LO. Lipoprotein profiles in Yupik Eskimos: the Alaska-Siberia Project. *Arctic Medical Research*. 1996; 55:165–173. [PubMed: 9115542]
- Ferrara CM, Kumar M, Nicklas B, McCrone S, Goldberg AP. Weight gain and adipose tissue metabolism after smoking cessation in women. *International Journal of Obesity and Related Metabolic Disorders : Journal of the International Association for the Study of Obesity*. 2001; 25:1322–1326.
- Froom P, Melamed S, Benbassat J. Smoking cessation and weight gain. *Journal of Family Practice*. 1998; 46:460–464. [PubMed: 9638109]
- Howard BV, Devereux RB, Cole SA, Davidson M, Dyke B, Ebbesson SO, Epstein SE, Robinson DR, Jarvis B, Kaufman DJ, Laston S, MacCluer JW, Okin PM, Roman MJ, Romenesko T, Ruotolo G, Swenson M, Wenger CR, Williams-Blangero S, Zhu J, Saccheus C, Fabsitz RR, Robbins DC. A Genetic and Epidemic logic Study of Cardiovascular Disease in Alaska Natives (GOCADAN):

Design and Methods. *International Journal of Circumpolar Health*. 2005; 64:206–221. [PubMed: 16050315]

John U, Meyer C, Hanke M, Volzke H, Schumann A. Smoking status, obesity and hypertension in a general population sample: a cross-sectional study. *QJM*. 2006; 99:407–415. [PubMed: 16687420]

Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure. The Sixth Report of the Joint National Committee on detection, evaluation, and treatment of high blood pressure (JNC VI). *Archives of Internal Medicine*. 1997; 157:2413–2446. [PubMed: 9385294]

Kriska AM, Knowler WC, LaPorte RE, Drash AL, Wing RR, Blair SN, Bennett PH, Kuller LH. Development of questionnaire to examine relationship of physical activity and diabetes in Pima Indians. *Diabetes Care*. 1990; 13:401–411. [PubMed: 2318100]

Lahti-Koski K, Pietinen P, Heliövaara M, Vartiainen E. Associations of body mass index and obesity with physical activity, food choices, alcohol intake, and smoking in the 1982–1997 FINRISK Studies. *American Journal of Clinical Nutrition*. 2002; 75:809–817. [PubMed: 11976153]

Lanier, AP, Ehrsam, G., Sardidge, J. Alaska Native mortality 1989–1998. Office of Alaska Native Health Research, Division of Community Health Services, Alaska Native Tribal Health Consortium; 2002.

McLaughlin JB, Middaugh JP, Utermohle CJ, Asay ED, Fenaughty AM, Eberhart-Phillips JE. Changing patterns of risk factors and mortality for coronary heart disease among Alaska Natives, 1979–2002. *Journal of the American Medical Association*. 2004; 291:2545–2546. [PubMed: 15173144]

Nobmann ED, Ebbesson SOE, White RG, Schraer CD, Lanier AP, Bulkow LR. Dietary intakes among Siberian Yupiks of Alaska and implications for cardiovascular disease. *International Journal of Circumpolar Health*. 1998; 57:4–17. [PubMed: 9567571]

Nobmann ED, Ponce R, Mattil C, Devereux R, Dyke B, Ebbesson SO, Laston S, MacCluer J, Robbins D, Romenesko T, Ruotolo G, Wenger CR, Howard BV. GOCADAN study, 2000–2003. Dietary intakes vary with age among Eskimo adults of Northwest Alaska in the GOCADAN study, 2000–2003. *Journal of Nutrition*. 2005; 135:856–862. [PubMed: 15795447]

Ockene I, Miller N. For the American Heart Association Task Force on Risk Reduction Cigarette Smoking, Cardiovascular Disease, and Stroke. A Statement for Healthcare Professionals From the American Heart Association. *Circulation*. 1997; 96:3243–3247. [PubMed: 9386200]

Peterson, E., Fenaughty, A., Eberhart-Phillips, JE. Tobacco in the great land, A portrait of Alaska's leading cause of death. Anchorage, AK: Section of Epidemiology, Division of Public Health, Alaska Department of Health and Social Services; 2004.

Rasmussen F, Tynelius P, Kark M. Importance of smoking habits for longitudinal and age-matched changes in body-mass index: a cohort study of Swedish men and women. *Preventive Medicine*. 2003; 37:1–9. [PubMed: 12799123]

Risica PM, Ebbesson SOE, Schraer CD. Body fat distribution in Alaskan Eskimos of the Bering Straits Region: The Alaska Siberia Project. *International Journal of Obesity and Related Metabolic Disorders : Journal of the International Association for the Study of Obesity*. 2000; 24:171–179.

Risica PM, Schraer C, Ebbesson SOE, Nobmann ED, Caballero B. Overweight and obesity in Alaskan Eskimos of the Bering Straits Region: The Alaska Siberia Project. *International Journal of Obesity and Related Metabolic Disorders: Journal of the International Association for the Study of Obesity*. 2000; 24:939–944.

Roman MJ, Pickering TG, Schwartz JE, Pini R, Devereux RB. The association of carotid atherosclerosis and left ventricular hypertrophy. *Journal of the American College of Cardiology*. 1995; 25:83–90. [PubMed: 7798531]

Roman MJ, Saba PS, Pini R, Spitzer M, Pickering TG, Rosen S, Alderman MH, Devereux RB. Parallel cardiac and vascular adaptation in hypertension. *Circulation*. 1992; 86:1909–1918. [PubMed: 1451262]

SAMSHA, Office of Applied Studies. National Household Survey on Drug Abuse. CAI; 1999.

SAMSHA Office of Applied Studies. Results from the 2002 National Survey on Drug Use and Health: National findings. Rockville, MD: Substance Abuse and Mental Health Services Administration; 2003. (DHHS Publication No. SMA 03–3836, NHSDA Series H–22)

- SAS Institute Inc.. Logistic regression examples using the SAS system, version 6. Cary, NC: SAS Institute Inc.; 1995.
- Schraer CD, Ebbesson SOE, Adler AI, Cohen JS, Boyko EJ, Nobmann ED. Glucose tolerance and insulin resistance syndrome among St. Lawrence Island Eskimos: The Alaska-Siberia Project. *International Journal of Circumpolar Health*. 1998; 57(Suppl 1):348–354. [PubMed: 10093304]
- Schraer CD, Ebbesson SOE, Boyko EJ, EJ Nobmann E, Adler A, Cohen J. Hypertension and diabetes among Siberian Yupik Eskimos of St. Lawrence Island, Alaska. *Public Health Reports*. 1996; 111(Suppl 2):51–52. [PubMed: 8898775]
- Schraer CD, Risica PM, Ebbesson SOE, Go OT, Howard BV, Mayer AM. Low fasting insulin levels in Eskimos compared to American Indians: Are Eskimos less insulin resistant? *International Journal of Circumpolar Health*. 1999; 58:272–280. [PubMed: 10615832]
- Welty TK, Lee ET, Yeh J, Cowan LD, Go O, Fabsitz RR, Le NA, Oopik AJ, Robbins DC, Howard BV. Cardiovascular disease risk factors among American Indians: The Strong Heart Study. *Am J Epidemiol*. 1995; 142:269–287. [PubMed: 7631631]

TABLE 1

Summary characteristics of the GOCADAN Study Population, by gender, 2000–2004 (N = 1,208).

	Women (n = 675)		Men (n = 533)	
	Mean or %	SD	Mean or %	SD
Age (years)	42.9	16.2	42.0	15.7
BMI (kg/m ²)	28.6	6.3	26.6	5.1
Overweight/obese (%)	66%	--	56%	--
Education (years)	12	2.2	12	2.7
Systolic BP (mmHg)	118	16	121	13
Hypertension (%)	20%	--	23%	--
Fibrinogen (mg/dL)	334	101	328	104
Diabetes (%)	5%	--	2%	--
Carotid plaque (%)	31%	--	35%	--
Physical activity (METs)	67.9	68	79.3	94.3
Daily caloric intake (kcal)	2850	1453	3475	1576

BMI = body mass index, BP = blood pressure.

Participants ranged in age from 18 to 75.

TABLE 2

	Among All Participants			Among Ever-Smokers			
	Ever Smoked n=974 (%)	Current Smoke n=721 (%)	Quit Smoking n=253 (%)	Age Began Smoking (mean)	Cigarettes/Day (mean)	Pack-years (mean)	% Who Quit
All	81	60	21	16.5	11.4	14.8	26
Gender							
Women	79	57	22	16.8	10.0	12.5	28
Men	83	63	20	16.1*	13.0*	17.5*	24*
Age (yrs)							
18-25	76	63	13	14.9 [‡]	8.6	3.0	17
25-34	84	70	14	15.9	10.1	7.0	17
35-44	82	65	17	16.3	11.4	13.6	21
45-54	86	62	24	16.7	13.3	20.8	28
55-64	85	53	32	18.1	12.8	25.6	38
65-74	66	33	33	18.5	13.9	35.3	50
75+	57	14	43	20.3	12.1	26.9	75
Education							
< 12 years	81	60**	21	16.4	12.0	17.3	26
12 years	85	67**	18	16.3	11.6	14.4	21
13+ years	71**	41**	29	17.2	10.2**	12.9**	41**
Household Income							
\$0-5,000	85 [‡]	76	9	16.1	11.6	15.5	11 [‡]
\$5,000-10,000	93	76	17	16.7	11.4	17	18
\$10,000-15,000	80	57	23	17.1	11.6	16.8	29
\$15,000-20,000	84	57	27	16.2	12.0	15.5	32
\$20,000-25,000	77	54	23	15.7	11.2	14.2	30
\$25,000-35,000	82	59	23	17.2	12.5	15.1	28
\$35,000-50,000	76	49	27	16.2	11.9	14.7	36

	Among All Participants			Among Ever-Smokers			
	Ever Smoked n=974 (%)	Current Smoke n=721 (%)	Quit Smoking n=253 (%)	Age Began Smoking (mean)	Cigarettes/Day (mean)	Pack-years (mean)	% Who Quit
\$50,000+	68	37	31	17.0	10.8	14.1	46
Physical Activity							
Quartile 1	77	56	21	16.9	11.6	17.1	27
Quartile 2	82	62	20	16.4	11.3	15.7	24
Quartile 3	82	58	24	16.3	11.7	14.6	29
Quartile 4	86	68	18	16.1	11.3	12.1	21
Daily Caloric Intake (kcal)							
Quartile 1	69	44	25	17.9	11.0	13.7	36
Quartile 2	77	55	22	16.6	10.0	13.5	29
Quartile 3	85	63	22	15.9	12.3	15.1	26
Quartile 4	88	75	23	16.1	11.5	14.9	26

* Difference between genders is significant, adjusting for age, village, education, income, and physical activity - all p < 0.02

** Difference between education categories is significant, adjusting for age, village, gender, income, and physical activity; all p < 0.02

† Income, treated as an ordinal 8-category variable, was significant, adjusting for age, village, gender education, and physical activity all p < 0.0001.

‡ p < 0.0001 for age category as a continuous variable. For analyses of smoking phenotypes other than age when smoking began, age was treated as a confounder rather than a demographic factor of interest, so significance is not reported for these analyses.

TABLE 3

Adjusted odds of carotid plaque in current smokers compared to all non-smokers, GOCADAN 2000–2004.*

Age (yrs)	% of Non-smokers with plaque	% of Smokers with plaque	Adjusted OR	95% CI	<i>p</i>
18–24	0	0	--	--	--
25–34	7	2	0.05	0.06–1.1	<i>0.09</i>
35–44	13	21	1.8	0.5–6.6	<i>0.36</i>
45–54	39	54	1.8	1.1–9.0	<i>0.03</i>
55–64	69	88	4.4	1.0–13.2	<i>0.02</i>
65+	92	100	--	--	--
Adjusted Mantel-Hansel odds ratio:			2.1	(1.2–3.7)	<i>0.01</i>

* Adjusted for gender, hypertension, diabetes, BMI, village, income, education, and physical activity.