Current Smoking and Type 2 Diabetes Among Patients in Selected Indian Health Service Clinics, 1998–2003

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Several clinical and large prospective studies have reported significant links between smoking and the development of diabetes, micro- and macrovascular complications, and impairment of metabolic control. Fay reported a linear dose relationship of incident diabetes with increasing number of pack years of smoking, and an odds ratio of 5.7 (P<.001) for current smokers with 20 or more pack years of smoking. Smoking is an independent risk factor for cardiovascular disease, and acute and chronic tobacco exposure significantly impairs glucose tolerance and increases insulin resistance. Conversely, improvement in insulin sensitivity and elevated levels of high-density lipoprotein cholesterol both occur after smoking cessation.

However, most studies in the general population have shown the prevalence of tobacco use to be similar among those with or without diabetes (26%), but many of these studies have used self-report of diabetes and tobacco use.

Diabetes is the fourth leading cause of death for American Indian and Alaska Native (AIAN) populations and is the major independent risk factor for cardiovascular disease, the leading cause of death among American Indians and Alaska Natives. AIAN populations have the highest reported tobacco use of any US ethnic group—40.4% reported from 1999–2001 Centers for Disease Control and Prevention (CDC) data, and 32% reported from 2005 CDC data. However, data that show smoking prevalence stratified by type 2 diabetes status are scarce. Although Indian Health Service (IHS) data are the most comprehensive nationally based AIAN health data available, the data report age, gender, socioeconomic status, and mortality rates but not disease or lifestyle behavior prevalence rates.

In other national databases, only small samples of American Indians and Alaska Natives are included and therefore prevalence estimates are not representative or reliable. Many American Indians and Alaska Natives included in these data sets are misclassified as another race/ethnicity and vice versa (i.e., many people who do not have legitimate AIAN heritage self-identify as American Indian and Alaska Native).

OBJECTIVES. In non-American Indian/Alaska Native groups, current smoking prevalence is similar for those with or without diabetes (26%). We analyzed current smoking prevalence in American Indian/Alaska Natives by diabetes status.

METHODS. Data were extracted from Indian Health Service clinic visit information from 1998 to 2003. After consolidation into unique patient records, the sample comprised 71,221 patients aged 14 years or older with both diabetes and current smoking information.

RESULTS. Cross-sectional results indicated that diabetic American Indian/Alaska Natives were significantly more likely than those without diabetes to be current smokers (29.8% vs 18.8%; P<.01). Smoking rates were 2 to 3 times higher among diabetic American Indians and Alaska Natives for each age category (P<.001), and current smokers with diabetes were more likely than nonsmokers to have glycosylated hemoglobin A1c levels at 8.0% or higher (P<.05).

CONCLUSIONS. American Indian/Alaska Natives with diabetes at all sites and age categories were found to smoke at significantly higher rates than those without diabetes. Smoking cessation programs should target diabetic patients to more effectively prevent complications and promote successful management of diabetes in American Indians/Alaska Natives. (Am J Public Health. 2007;97:XXX–XXX. doi:10.2105/AJPH.2006.104042)
and stored in the Patient Care Component Package. IHS patient clinic measurements are stored in the Laboratory Package. We used the Native American Data Extraction and Surveillance software program (Cimarron Medical Informatics, LLC) to extract more than 250 clinical variables from each visit between 1998 and 2003 at 8 different regional IHS federal and tribally owned health facilities. The Native American Data Extraction and Surveillance software program has been validated and found to have greater than 97% accuracy when compared with data reviewed from the actual paper chart.15

We extracted a total of 5 091 989 unique visits. Visits to clinics outside the IHS-defined service areas were excluded, which left 4828 228 patient visits. With year of birth, gender, and patient record information, visit data were consolidated into unique patient records, which yielded a sample of 254 702 patients who resided within IHS service areas. Prior to consolidation, 36 760 patient records were excluded because of patients’ residence outside of IHS service areas. The out-of-residency group was compared with the in-residence group, and mean ages were similar, as were distributions of gender and age categories.

Diabetes was defined as a diagnosis of type 2 diabetes at any time during the 5-year period. A diagnosis was counted if it was for any of the 10 levels of International Classification of Diseases, Ninth Revision, Clinical Modification—coded diagnoses (code=250).17 Current smoking was taken from any 1 of 4 health factor variables, or from tobacco use indicated on the problem-list variables at any time during the 5-year period. Health factor variables were collected upon clinic visit arrival, before the patient saw any health practitioners, and problem-list variables were recorded by the health practitioner. Because both the health factor and problem-list variables may not have been consistently recorded at all clinic visits across all sites, we combined these 2 variables to identify the largest number of current smokers.

Age was defined as age as of June 30, 2000. Height, weight, body mass index (weight in kilograms divided by height in meters squared), and HbA1c levels were averaged over the 5-year period. Approximately 71% (n=5218) of those with diabetes (n=7304) had recorded values for HbA1c levels; 25% of this group had 1 measurement, and 16% had 2 measurements. An HbA1c at 8.0% or higher was chosen as the analyses cutpoint.15

From the total patient data set (n=254 702), 69 923 patients aged younger than 14 years were excluded because smoking when aged younger than 14 years is generally contemplated and experimental. Also excluded were those with type 1 diabetes (n=63) and 1239 patients with data entry errors indicating both type 1 and type 2 diabetes and those who had missing International Classification of Diseases, Ninth Revision, Clinical Modification codes17 (n=3107) or smoking status information (n=885). The total remaining was 179 485 patients.

To protect the confidentiality of specific tribal communities, sites will be referred to solely by state names. Each of the IHS regional and tribally owned facilities represents numerous distinct tribal communities, which will not be named. These data do not represent all American Indians and Alaska Natives in each of the named states and should not be considered a state-based comparison. In some cases, the IHS service areas cross state boundaries. No patient names, addresses, or social security numbers were extracted.

Three of the sites did not give institutional review board approval to present their data because of tribal concerns about the potential revelation of tribal names—they were the only tribe in the state, and thus, if the state were tribe in the state, and thus, if the state were named, it would be essentially the same as revealing their tribal name. Therefore, data from 5 of the 8 sites will be reported here for a final total sample size of 71 221 patients, representing health facilities in New Mexico (n=25 008), Minnesota (n=5715), Oklahoma (n=29 479), South Dakota (n=4398), and Wyoming (n=6621).

Statistical Analyses

We outputted Native American Data Extraction and Surveillance data as ASCII data and analyzed it using SAS version 9.1 (SAS Institute Inc, Cary, NC). Significant differences in proportions for site comparisons, such as current smoking stratified by type 2 diabetes, and prevalence of HbA1c levels at 8.0% or higher, stratified by current smoking, were estimated using the age-adjusted Mantel–Haenszel χ² statistic. We estimated levels of continuous variables adjusted for age, such as mean age at diabetes, diagnoses, and mean diabetes duration stratified by gender, age categories, and site using the least squares means option of the SAS generalized linear regression procedure.

RESULTS

Mean age for the entire group was 35.0 years and was similar by gender and by site (Table 1). Age 18 years was chosen as the highest cutpoint value in the lowest age category because it is the legal age to buy cigarettes. According to tobacco industry information,18 most people do not initiate smoking after age 24 years, the second age category cutpoint. Age categories were fairly evenly distributed; the smallest category was age 14 to 17 years (12.0%), and the largest category was age 35 to 49 years (25.1%).

Overall, current smoking prevalence was 19.7% and was similar by gender. The highest smoking rate was in the group aged 35 to 49 years (24.5%), and the lowest rate was in the group aged 14 to 17 years (10.7%). Current smoking varied considerably by site, from 3.6% in New Mexico to 51.5% in Wyoming.

Diabetes prevalence was 10.3% overall and was slightly higher in women (10.6%) than in men (9.8%). Slightly higher rates in women persisted in 4 of the 5 sites (data not shown). Older age was associated with higher diabetes rates with the highest prevalence among those aged 50 years or older (29.8%). Diabetes rates by site varied from 10.0% in New Mexico to 13.4% in Wyoming. Mean age at diabetes diagnosis was 47 years, similar by gender, with the overall lowest age found in New Mexico (44.5 years) and the highest age found in Oklahoma (49 years).

Mean age-adjusted duration of diabetes was 5.3 years overall and was similar by gender. When stratified by site, mean duration of diabetes ranged from 3.5 years in Oklahoma to 7.5 years in Wyoming. Relative to other sites, age-adjusted diabetes duration for non-smokers compared with smokers was similar for New Mexico (6.5 vs 6.7 years) and South
Dakota (4.9 vs 5.0 years), significantly shorter in Oklahoma (3.3 vs 3.8 years; \( P < .05 \)) and Minnesota (6.3 vs 7.3 years; \( P < .05 \)), and significantly longer in Wyoming (8.1 vs 6.9 years; \( P < .01 \)).

The overall mean age-adjusted \( \text{HbA}_1c \) value was 7.5\% (and almost half \( n = 22,933, 44\% \)) of those with diabetes had measured \( \text{HbA}_1c \) values that were high. In diabetic American Indians and Alaska Natives, current smokers were more likely than were nonsmokers to have elevated age-adjusted prevalence of high \( \text{HbA}_1c \) levels: 45.0\% versus 43.8\% (Figure 2). In women, age-adjusted rates of high \( \text{HbA}_1c \) levels were 43.0\% in current smokers versus 39.9\% in nonsmokers, and in men, rates were 49.3\% versus 47.5\%, respectively. Prevalence of high \( \text{HbA}_1c \) levels were increased among smokers aged 25 to 34 years and significantly higher in smokers aged 50 years or older (\( P < .05 \); data not shown). New Mexico and Oklahoma data showed a significantly elevated prevalence of high \( \text{HbA}_1c \) levels among current smokers (\( P < .05 \) and \( P < .01 \), respectively) compared with nonsmokers. Minnesota and Wyoming reported the same pattern, but rates were nonsignificant (Figure 2).

**DISCUSSION**

**Diabetes Rates**

Age-adjusted diabetes prevalence in our sample (approximately 10.0\%) were slightly higher than those reported by IHS in 1997 (7.9\%) and lower than the rates reported in the IHS Diabetes Care and Outcomes Audit data (74,408 patient records)—approximately 12\% in 1998, and 15\% in 2003. Diabetes rates varied by site, with the lowest rate in New Mexico (9\%) and the highest rate in Wyoming (13\%). The higher rate in Wyoming may reflect the combination of the second oldest mean age of all sites and one of the highest overall mean body mass indexes (31.3 kg/m\(^2\)).

Overall mean duration of diabetes in our study was lower at 5.3 years than the 8.3 years reported in similar data from the IHS Diabetes Care and Outcomes Audit, 1995–2001, among participants aged 18 years and older. We suspect this difference was most likely caused by differences in the age distributions of our sample compared with the IHS sample, but diabetes duration by age categories data for the IHS data were not available for comparison. However, our mean age was 35 years compared with 55 years reported in the same study. When age-adjusted duration of diabetes was stratified by current smoking status, Wyoming (\( P < .001 \)) had a longer duration of diabetes in the nonsmoking group, indicating either that the longer the duration since the diagnosis of diabetes, the more likely patients were to have stopped smoking, or that there was an increase in mortality, possibly because of macrovascular complications. Conversely, in the remaining 4 sites, we found a longer duration of diabetes in the current smoking group (\( P < .05 \) in Oklahoma and Minnesota), possibly indicating that smoking was initiated before a diabetes diagnosis was made. This finding emphasizes the need for smoking cessation programs targeted to those with a longer duration of diabetes, because they may have been smoking longer, and quitting smoking as early as possible helps prevent complications.

**Smoking Rates**

Compared with the current AIAN smoking rate of 40.4\% among those aged 18 years...
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and older reported from CDC data in 2004,9 and 32% found among 2005 CDC data,10 the age-adjusted overall current smoking rate in our study was lower, at 19.7%, partially because of the inclusion of those aged 14 to 18 years. When stratified by site, smoking rates varied extensively from 51% in Wyoming and 47% in South Dakota to 4% in New Mexico. These discrepancies may be caused by inflated national rates, because culturally inappropriate questionnaire design and confounding by ceremonial tobacco use has plagued national data sets. If separate questions regarding ceremonial tobacco use versus recreational or regular use of cigarettes are not asked, then those who use tobacco only for ceremonial purposes might be misclassified as current smokers. In addition, accurate recording of tobacco use data either on the problem list or in the health factor variables may not be consistent because of differences in IHS clinic practices.

Data from the Strong Heart Study reported current smoking among AIAN men to be highest in Oklahoma (42%), followed by the Dakotas (40%) and Arizona (31%). Current smoking among AIAN women was highest in the Dakotas (48%) and lowest in Oklahoma (27%) and Arizona (20%).27 Smoking rates reported here for Oklahoma, South Dakota, and Wyoming were relatively similar to the Strong Heart Study data. Smoking rates in Southwestern American Indians and Alaska Natives are approximately 20%,24,25 somewhat higher than that reported here for New Mexico. A recent study of 866 intertribal women in Minnesota and Wisconsin estimated smoking to be much higher among this group (65%) than the 13.7% we found for Minnesota.26 However, the data from that study were collected from a research study specifically designed to investigate cardiovascular risk factors, not from clinic visit data in which documentation of smoking behaviors may or may not be consistently collected or entered into each clinical Resource Patient Management System data system.

Smoking Rates by Diabetes Status

Self-reported data from both the National Health Interview Survey27 and the Behavioral Risk Factor Surveillance System28 have shown that diabetic patients smoke at rates equivalent to the general population, approximately 26% to 27%. Until our study, comparative smoking rates for a large national AIAN population, stratified by diabetes status, have not been reported. We found diabetic American Indians and Alaska Natives to smoke at rates considerably higher than non-diabetic American Indians and Alaska Natives (P<.001 at 4 sites). Smoking rates among women were similar to those among men, although women had slightly higher rates of diabetes alone. However, when stratified by diabetes status, smoking was higher in diabetic men than in women, possibly indicating that diabetic women were more compliant with smoking cessation once they were given a diagnosis of diabetes. This finding is somewhat consistent with Henderson et al.,29 who reported that participants, after a 4-year follow-up in the Strong Heart Study, were more likely to quit smoking compared with those without diabetes. However, their data were not stratified by gender so it is not known if those with diabetes who quit smoking were predominantly women or men. The patterns observed in our data persisted within all age
categories, thus emphasizing the increasing risk of diabetes complications in the youngest groups and the need for age- and gender-targeted smoking cessation programs.

**Smoking Rates by HbA1c Status**

Some studies have reported an increase in HbA1c levels with smoking,\(^{30,37}\) whereas others have found no direct associations.\(^{32}\) Improvement in HbA1c to near-normal levels helps prevent or slow the progression of microvascular complications and improve cardiovascular disease–related risk factors including insulin resistance. Facchinetti et al.\(^{33}\) demonstrated that smokers were insulin resistant, and, more recently, Targher et al.\(^{34}\) reported aggravated insulin resistance in smokers. We found a higher overall prevalence of HbA1c values at 8.0% or higher among current smokers. This pattern was similar for women and men and those aged older than 25 years. Stratification by clinic site showed similar patterns at 4 sites. These results may indicate a high prevalence of insulin resistance among this AIAN population, thus increasing the likelihood of cardiovascular disease complications.

**Limitations**

It is possible that because of the emphasis on diabetes care in most IHS facilities, patients with diabetes may have simply been asked more often if they currently smoked, thus inflating their smoking prevalence estimates. Unfortunately, we have no way of determining whether this is true, because the recording of tobacco use varies by IHS clinic facilities because of differing roles and behaviors of health care providers. In addition, the Tobacco Use and Dependence Clinical Practice Guideline from the US Public Health Service includes tobacco documentation, but it is not as yet mandated at all IHS clinic sites. Recent research into general clinical practice regarding documentation and screening for tobacco use at every visit reports that providers can be biased in their documentation. In one study, clinicians were more likely to document smoking among men, Whites versus African Americans, patients who were aged 45 to 64 years, and current smokers, than among other groups.\(^{35}\) Again, variation in IHS clinic practice as well as provider recording bias may account for some of the site variation in overall smoking rates in the present study as well as current smoking rates stratified by diabetes status.

Tobacco use data recorded in IHS clinics are limited. Some clinics may emphasize recording health factor variables, some clinics may use the problem list to record smoking status, and others may record both. However, when these variables are part of standard practice at an IHS clinic site, they are updated at each visit, so determination of smoking status by using both health factor and problem-list variables from all visits during the 5-year time span most likely limited misclassification. The tobacco data did not include detailed information on number of cigarettes smoked per day, age at initiation or duration of tobacco use, quit attempts, strength of nicotine addiction, brand preferences, or environmental tobacco smoke exposure. These additional types of data, particularly age at tobacco use initiation, might serve to elucidate whether diabetic patients were being asked more often if they smoke as well as help to explain other links between diabetes and smoking. Because the variables we chose to use to define smoking status were collected as standard clinic visit procedure both before and during interaction with a health practitioner, we surmise data were recorded in at least 1 of these data fields regardless of diabetes status, thus limiting confounding.

Controlling for education and income would have been appropriate because smoking and diabetes are associated with these demographic variables, but these data were not available. The data used in this study were consolidated from clinic visit data rather than collected during the course of a study in which a specific design and survey instrument assessed all pertinent confounders.

These results cannot be generalized to the entire AIAN population. Data reported here represent IHS data only, and further, only a portion of IHS data. Although IHS provides some of the best current data, the total AIAN population is much greater than the number served by IHS facilities. The 2000 US Census\(^{36}\) estimated that 4.1 million people were American Indian and Alaska Native alone or in combination with other races, and IHS estimated its user population at 1.6 million in 2004.\(^{37}\)

**Strengths**

Such a large data set is unusual for any US ethnic minority group and allowed analyses to be stratified by site. If the analyses had been conducted solely on aggregate data, tribal/regional variations would have been lost. Wilson et al.\(^{21}\) eloquently pointed out that IHS data analyzed across considerable numbers of patients can lead to IHS system-wide changes in diabetes care as well as in long-range evaluation of laws and policies affecting the health of American Indians and Alaska Natives.

Diabetes status was physician diagnosed from clinical measures, not self-report, thus strongly limiting misclassification of diabetes status. We are confident we captured the largest number of current smokers with the least amount of misclassification.

**Conclusions**

These findings demonstrate the need for IHS federal and tribal health facilities to step up their tobacco screening, documentation, surveillance, and cessation efforts for all patients, most especially diabetic American Indians and Alaska Natives. Smoking in diabetic patients complicates glucose management, is a well-established risk factor for nephropathy and retinopathy, and is associated with insulin resistance, a major risk factor for cardiovascular disease. Early tobacco intervention in younger diabetic American Indians and Alaska Natives is critical to curbing the growing cardiovascular disease–complication rates.

There is evidence indicating that diabetic smokers may have a more difficult time with cessation efforts than nondiabetic smokers because of stressors associated with diabetes management and medications.\(^{22}\) A recent study concluded that diabetic smokers were less likely to be compliant with their diabetes care—less interested in quitting, more likely to be depressed, and less likely to exercise, check glucose levels regularly, or have regular diabetes care.\(^{38}\) Tobacco cessation efforts aimed at American Indians and Alaska Natives need to take such issues when planning intervention programs into consideration.

The cost-effectiveness and safety of smoking cessation is considered the "gold standard" for other preventive behaviors.\(^{22}\) We
recommend the expansion of clear national guidelines for consistent and accurate collection of tobacco use data for all HHS clinic visits of patients aged older than 10 years. Accurate assessment of tobacco-use behaviors helps focus tobacco cessation efforts in a more effective and culturally specific manner, providing for the successful prevention and management of diabetes and future complications.

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**Contributors**
D.J. Morton originated the study, conducted all data analyses and interpretation, led the writing, and managed all authors’ input. M. Garrett conducted the Indian Health Service data extract and assisted with background information, limitations, and analyses. J. Reid assisted with data management and helped complete all analyses. D.L. Wingerd assisted with article revisions.

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**Human Participant Protection**
Institutional review boards from each of the following institutions approved the study: University of California, San Diego; San Diego State University; Oklahoma City and Aberdeen Indian Health Services Area Offices; and several tribal organizations in New Mexico, Oklahoma, Minnesota, and Wyoming.

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