Chapter 34

Diabetes in North American Indians and Alaska Natives

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SUMMARY

The epidemic of non-insulin-dependent diabetes mellitus (NIDDM) in Native American communities has occurred primarily during the second half of this century. Although NIDDM has a genetic component, with rates highest in full-blooded Native Americans, the incidence and prevalence of the disease have increased dramatically as traditional lifestyles have been abandoned in favor of westernization, with accompanying increases in body weight and diminished physical activity. Anthropologic studies have shown that several tribes perceive diabetes as an assault from outside the community. Diabetes was once described as benign in American Indians; now, diabetes and its complications are major contributors to morbidity and mortality in all Native American populations, except the isolated Arctic groups whose lifestyles remain relatively unchanged. Insulin-dependent diabetes mellitus (IDDM) is rare in Native Americans and most cases of IDDM are found in individuals with significant non-Native American ancestry.

Much of our understanding of the natural history of NIDDM in North American Indians is derived from the longitudinal epidemiologic studies of the Pima Indians in southern Arizona. The relationship of obesity to subsequent diabetes as described in studies of the Pimas is present in all Native American populations. Native American communities experience high rates of microvascular complications from diabetes, although the rates of cardiovascular disease differ from tribe to tribe. The differences may reflect genetically based variations in lipid metabolism or other coronary risk factors or, alternatively, differences in lifestyle. The extent of diabetes in Native American communities today demands public health programs that incorporate specific psychosocial and cultural adaptations for individual tribes.

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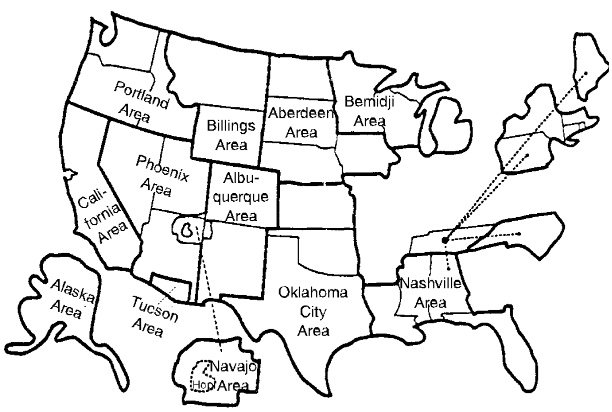
INTRODUCTION

Native Americans are a diverse group of people whose ancestors lived in North America before the European settlement. In the United States alone, there are more than 500 tribal organizations. In addition to their tribal affiliations, Native Americans are often distinguished by language and/or cultural groups, some of which extend across both the United States and Canada. Contemporary Native American populations live in urban areas and on reservations or reserves in both countries. In the United States, ~1.9 million individuals identified themselves in the 1990 Census as American Indian or Alaska Native, but only 1.2 million of these resided in the 33 reservation states served by the Indian Health Service (IHS), an agency of the U.S. Public Health Service[1,2]. Few data exist on the health of urban Native Americans in either the United States or Canada. Overall, the Native American populations of North America are young, with a median age in 1990 of 26 years, compared with 33 years for all races in the United States. In addition, Native Americans are disadvantaged both economically and educationally compared with the general U.S. population.

PREVALENCE

Because American Indians living on reservations are not included in U.S. national health surveys, data on the prevalence of diabetes in Native Americans residing in the United States are limited. Rates have been estimated from case registries maintained at health facilities, glucose testing at a community level, and surveys of self-reported diabetes. In the United States and Canada, prevalence estimates for diagnosed diabetes are available from health care facilities where care is provided at no charge to Native Americans. The IHS estimated the rates of diagnosed diabetes from

Figure 34.1
Indian Health Service Areas



Source: Indian Health Service

ambulatory care visits that covered 86% of the estimated 1 million American Indians served through the IHS in 1987[3]. Duplicate records were excluded by using unique patient identifiers. Rates were calculated for the regions shown in Figure 34.1. A similar estimate covering 76% of the Inuit and Canadian Natives living on reserves was also undertaken in 1987, using cases known to the Medical Services Branch of the Department of National Health and Welfare in Canada[4]. Crude and age-adjusted rates of diabetes from these two surveys are shown in Table 34.1[3,4]. The rates decreased toward the north and west in Canada. Although a similar trend was not apparent in the United States, rates in the far northwest were relatively low in both countries. Rates of diabetes were higher in women than in men in all Canadian provinces, a trend also found for the United States in current diabetes estimates by the IHS. Women had higher rates of diabetes (13.2%) than men (11.0%) in a special medical expenditure survey of American Indians eligible for IHS services conducted in 1987[5]. In the survey, the age- and sex-adjusted diabetes rate in individuals age ≥19 years was 12.2%, compared with 5.2% in the general U.S. population. A summary of published studies[6-24] of diabetes prevalence in individual tribes in North America is presented in Table 34.2. These studies used criteria of the World Health Organization (WHO) and the U.S. National Diabetes Data Group (NDDG) for diagnosis of NIDDM[25,26].

Table 34.1
Diagnosed Diabetes in Native American Communities in the U.S. and Canada, All Ages, 1987

	Crude prevalence per 1,000	Age-adjusted prevalence per 1,000
United States		
Tucson	76	119
Aberdeen	60	105
Phoenix	65	104
Albuquerque	55	94
Bemidji	53	92
Nashville	63	87
Billings	50	86
Oklahoma	49	60
Navajo	32	56
Portland	29	49
Alaska	9	15
All IHS	45	69
Canada		
Atlantic	43	87
Quebec	29	48
Ontario	46	76
Manitoba	28	57
Saskatchewan	17	39
Alberta	22	51
Yukon	7	12
NW Terr. Indian	5	8
NW Terr. Inuit	3	4
British Columbia	9	16

U.S. rates are age-adjusted to the 1980 U.S. population; Canada's rates are age-adjusted to the 1985 Canadian population.

Source: References 3 and 4

Striking increases in the prevalence of diabetes in recent years have been described in Pima Indians and other tribes[11,22,27-29]. Because the incidence of diabetes has also increased in Pimas, and presumably in other tribes, the increased prevalence in many tribes is probably due to an increased incidence and cannot be attributed solely to longer survival of diabetic individuals[27]. Figure 34.2 shows the prevalence of diabetes in Pima Indians in each of three time periods since 1965[27]. Appendix 34.1 compares prevalence of diabetes in Pima Indian men and women with prevalence of NIDDM in a sample of U.S. white men and women.

DETERMINANTS OF DIABETES

The longitudinal studies of diabetes conducted in Pima Indians since 1965 have provided extensive information about NIDDM and its natural history in American Indians. The form of diabetes that affects Pimas is characterized biochemically and immunologically as NIDDM, an observation that confirms the paucity of IDDM also noted in other tribes[27,30].

Table 34.2
Prevalence of Diabetes in North America Native Populations by Region

Reservation/Location	Tribe	Age	Date	Rate/1,000	Adjustment	Method	Reference
Southwest							
Tohono O'odham, AZ	Tohono O'odham	≥18	1985-86	183	None	Case registry w/record review	6
Gila River, AZ	Pima	30-64	1982-87	500	Age World pop.	Biennial community screening	7
New Mexico	Pueblo (Rio Grande)	≥35	1985	213	None	Case registry w/record review	8
Zuni, NM	Zuni	≥35	1985	282	None	Case registry w/record review	8
Jicarilla Apache, NM	Apache	≥35	1985	98	None	Case registry w/record review	8
Mescalero Apache, NM	Apache	≥35	1985	164	None	Case registry w/record review	8
Navajo, NM	Navajo	≥35	1985	165	None	Case registry w/record review	8
Arizona and New Mexico reservations	Apache	≥15	1987	101	Age U.S. 1980	Outpatient records not verified	9
Navajo, AZ and NM	Navajo	≥15	1987	72	Age U.S. 1980	Outpatient records not verified	9
Navajo, AZ	Navajo	20-74	1989	165	Age/sex U.S. 1980	Case registry community screening	10
Navajo, AZ	Navajo	≥20	1988	124	Age U.S. 1980	Community sample w/screening	11
Rocky Mountain West							
Fort Hall, ID	Shoshone/Bannock	All	1987	95	Age/sex U.S. 1980	Case registry w/chart review	12
Nez Perce, ID	Nez Perce	All	1987	105	Age/sex U.S. 1980	Case registry w/chart review	12
Blackfeet, MT	Blackfeet	≥15	1986	168	Age ≥15 U.S. 1980	Case registry w/chart review	13
Crow, MT	Crow	≥15	1986	85	Age ≥15 U.S. 1980	Case registry w/chart review	13
Fort Belknap, MT	Assiniboine/ Gros Ventre	≥15	1986	118	Age ≥15 U.S. 1980	Case registry w/chart review	13
Fort Peck, MT	Assiniboine/Sioux	≥15	1986	173	Age ≥15 U.S. 1980	Case registry w/chart review	13
Northern Cheyenne, MT	Northern Cheyenne	≥15	1986	59	Age ≥15 U.S. 1980	Case registry w/chart review	13
Wind River, WY	Shoshone/Arapaho	≥15	1986	125	Age ≥15 U.S. 1980	Case registry w/chart review	13
Utah and Colorado	Ute	≥15	1987	124	Age U.S. 1980	Outpatient records not verified	9
Northern Plains							
Cheyenne River, SD	Sioux	All	1987	106	Age U.S. 1980	Outpatient records not verified	14
Crow Creek, Lower Brule, SD	Sioux	All	1987	83	Age U.S. 1980	Outpatient records not verified	14
Devil's Lake, ND	Sioux	All	1987	111	Age U.S. 1980	Outpatient records not verified	14
Pine Ridge, SD	Sioux	All	1987	70	Age U.S. 1980	Outpatient records not verified	14
Rosebud, SD	Sioux	All	1987	82	Age U.S. 1980	Outpatient records not verified	14
Sisseton/Wahpeton, SD	Sioux	All	1987	64	Age U.S. 1980	Outpatient records not verified	14
Turtle Mountain, ND	Chippewa	All	1987	105	Age U.S. 1980	Outpatient records not verified	14
Standing Rock, ND/SD	Sioux	All	1987	125	Age U.S. 1980	Outpatient records not verified	14

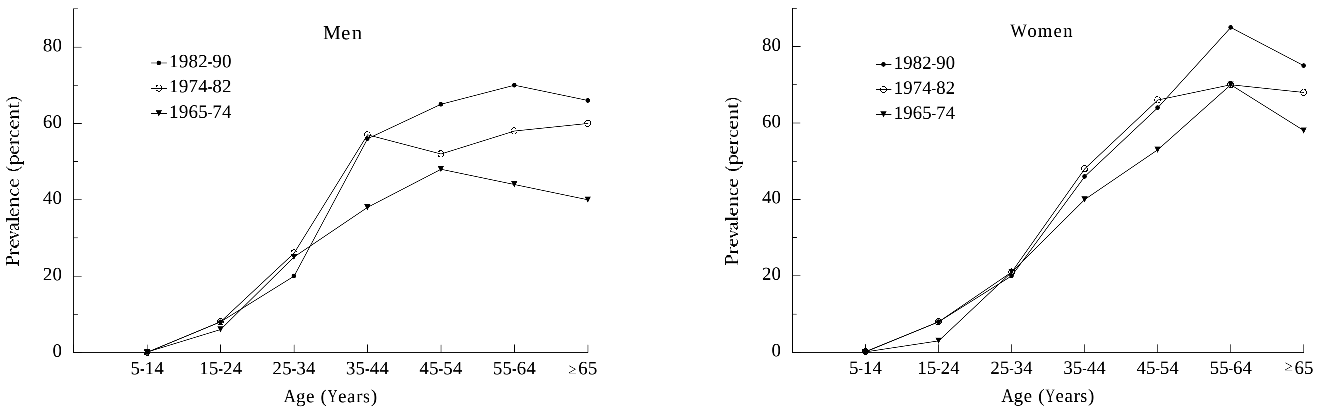
Table 34.2—Continued next page

Table 34.2—Continued

Reservation/Location	Tribe	Age	Date	Rate/1,000	Adjustment	Method	Reference
Yankton/Santee, SD	Sioux	All	1987	196	Age U.S. 1980	Outpatient records not verified	14
Winnebago/Omaha, NE	Winnebago/Omaha	All	1987	218	Age U.S. 1980	Outpatient records not verified	14
North and South Dakota reservations	Sioux	≥15	1987	117	Age U.S. 1980	Outpatient records not verified	9
Upper Midwest							
Red Lake, MN	Chippewa	All	1987	148	Age/sex U.S. 1980	Case registry verified/screening	15
MN and ND—Chippewa reservations combined	Chippewa	≥15	1987	144	Age U.S. 1980	Outpatient visits not verified	9
Ontario and Manitoba, Canada	Cree/Ojibwa	All	1983	28	None	Case registry w/chart review	16
SW Ontario, Canada	Oneida/Chippewa	≥5	1985	147	Age Canada 1985	Case registry w/chart review	17
Northeast							
St. Regis, NY	Mohawk	All	1989	49	Age U.S. 1980	Case registry w/chart review	18
River Desert/Lac Simon, Quebec, Canada	Algonquin	≥15	1989	150	None	Community survey	19
Nova Scotia, Canada	Micmac	All	1989	53	None	Case registry	20
South							
Choctaw, MS	Choctaw	All	1989	163	Age U.S. 1980	Case registry w/chart review	21
Cherokee, NC	Cherokee	All	1988	106	Age U.S. 1980	Case registry	22
Pacific Northwest							
Lummi, WA	Lummi	All	1987	40	Age/sex U.S. 1980	Case registry w/chart review	12
Tahola, WA	Quinalt	All	1987	50	Age/sex U.S. 1980	Case registry w/chart review	12
Makah, WA	Makah	All	1987	53	Age/sex U.S. 1980	Case registry w/chart review	12
Colville, WA	Colville	All	1987	52	Age/sex U.S. 1980	Case registry w/chart review	12
Spokane, WA	Spokane	All	1987	56	Age/sex U.S. 1980	Case registry w/chart review	12
Yakima, WA	Yakima	All	1987	75	Age/sex U.S. 1980	Case registry w/chart review	12
Umatilla, OR	Umatilla	All	1987	65	Age/sex U.S. 1980	Case registry w/chart review	12
Warm Springs, OR	Warm Springs	All	1987	75	Age/sex U.S. 1980	Case registry w/chart review	12
Far North							
Alaska	All native	All	1987	17	Age U.S. 1980	Case registry w/chart review	23
Alaska	Eskimo	All	1987	10	Age U.S. 1980	Registry verified w/chart audit	23
Alaska	Indian	All	1987	24	Age U.S. 1980	Case registry w/chart review	23
Alaska	Aleut	All	1987	29	Age U.S. 1980	Case registry w/chart review	23
Yukon Indian	Indian	All	1987	9	Age World pop.	Case registry not verified	24
NW Territories Indian	Indian	All	1987	7	Age World pop.	Case registry not verified	24
NW Territories Inuit	Inuit	All	1987	4	Age World pop.	Case registry not verified	24

Source: References are listed within the table

Figure 34.2
Prevalence of Diabetes in Pima Indians, by Age, Sex, and Time Period

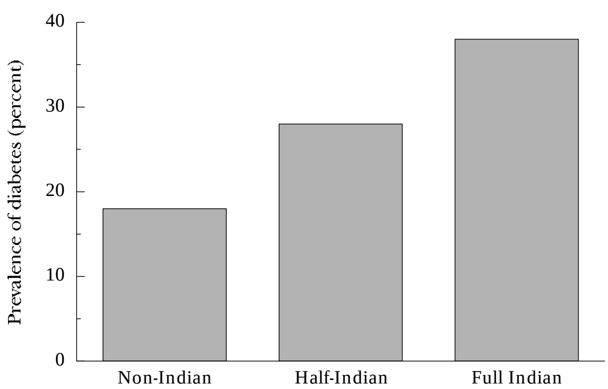


Source: Reference 27

GENETICS

Diabetes rates are highest in full-blooded Native Americans, as first observed in Choctaw Indians in 1965 and subsequently in other tribes[31-33]. The prevalence of diabetes in residents of the Pima community is highest in individuals of full Native American heritage (Figure 34.3)[33]. In Pimas, diabetes rates are highest in the offspring of parents who themselves developed diabetes at a young age (Figure 34.4)[34]. Diabetes is also familial in Oklahoma Indians, an observation suggesting that genetics and/or family lifestyles predispose individuals to NIDDM[35]. Although the precise genetic components of NIDDM have not been completely described in American Indians, a genetic marker linked with insulin resistance, a major factor in the pathogenesis of NIDDM, has been described in Pimas[36].

Figure 34.3
Prevalence of NIDDM in Pima Indians, by Indian Heritage



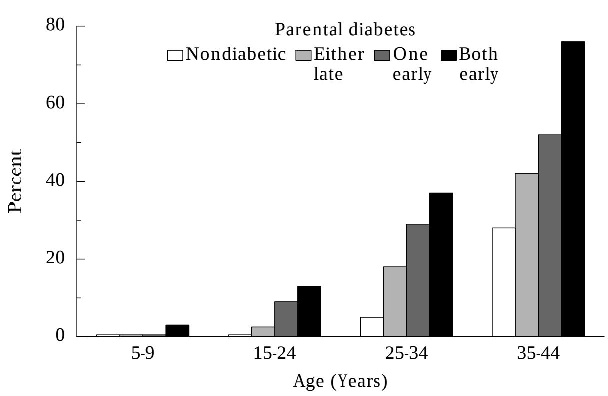
Data are age- and sex-adjusted.

Source: Reference 33

OBESITY

Obesity is a major risk factor for diabetes in Pimas and is widespread in many tribes, with increasing rates of obesity measured in several communities in the United States and Canada[11,37-41]. The interaction of obesity with genetic susceptibility to diabetes as measured by parental diabetes is shown in Figure 34.5 for Pimas[42]. A striking increase in obesity has occurred in Pimas in recent years (Figure 34.6)[27,43]. In addition,

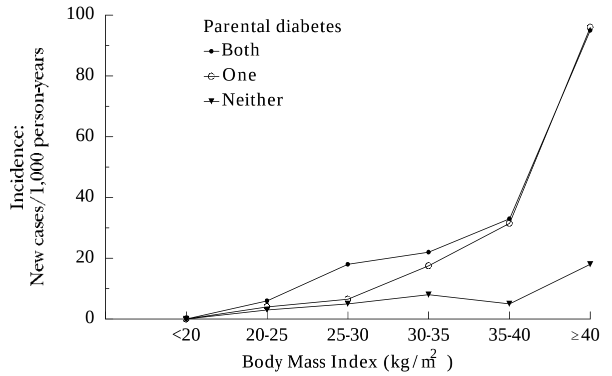
Figure 34.4
Prevalence of Diabetes in Pima Indians, by Presence and Age at Onset of Diabetes in the Parents



Persons for whom both parents had been examined were grouped into four groups according to parental diabetes: both early, one early, either late, or nondiabetic according to whether the parents had diabetes and whether the parental diabetes was diagnosed before or after age 45 years.

Source: Reference 34

Figure 34.5
Incidence of NIDDM in Offspring of Pima Indians by Body Mass Index and Parental Diabetes



Source: Reference 42

longer duration of obesity has been shown to increase the risk of diabetes[44].

Central obesity was characteristic of Canadian Indians studied in Manitoba and Ontario[40]. In young Pimas, waist-to-hip ratio, a measure of central obesity, was more strongly associated with diabetes than body mass index, a measure of overall obesity[38]. In Navajo women, a small study found an increased waist-to-hip ratio associated with a statistically significant increased risk of diabetes, but a similar association was not significant in Navajo men[45]. Appendix 34.2 shows data on obesity and other metabolic variables in Native American groups included in the Strong Heart Study.

LIFESTYLE

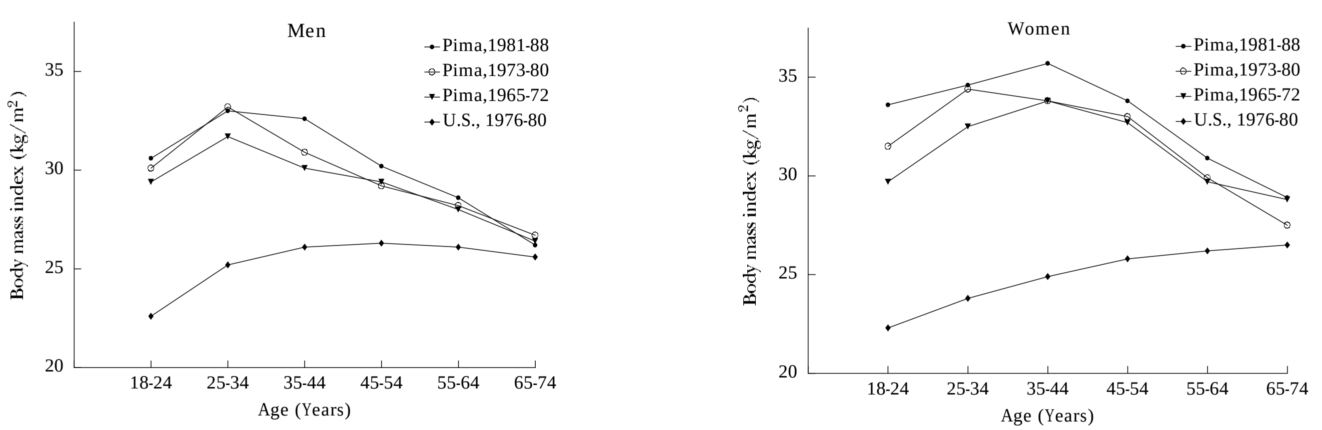
Both diet patterns and physical activity have changed markedly in Native American communities over recent decades. Although detailed longitudinal surveys are not available for most tribes, the disruption of traditional agriculture and hunting has resulted in increased consumption of fat—typical of the contemporary western diet. In Pimas, a high-calorie diet has been associated with the development of diabetes[27]. Carbohydrate intake was the single strongest predictor of NIDDM but was closely related to total calorie and fat consumption.

Physical activity has decreased as individuals have acquired motorized transportation and sedentary occupations. Diabetic Pimas reported less lifetime and current physical activity than nondiabetic individuals[46]. A recent case-control study in Zuni Indians showed the risk of presenting with diabetes decreased significantly with increasing physical activity, even after adjusting for obesity, suggesting that physical activity itself decreased the risk of NIDDM independently of body weight[47].

PATHOGENESIS

Studies of the pathogenesis of NIDDM in Pimas indicate that insulin resistance, as measured by nonoxidative glucose disposal, is an early metabolic defect[48]. Longitudinal studies have found that insulin secretion and insulin resistance increase as individuals develop impaired glucose tolerance[49]. Insulin levels then fall as frank NIDDM develops, often at a relatively young age[50,51].

Figure 34.6
Mean Body Mass Index in Pima Indians and the U.S. White Population



Data for U.S. whites are from the Second National Health and Nutrition Examination Survey.

Source: References 27 and 43

Energy metabolism and obesity have been studied in an attempt to characterize a "thrifty gene"[52]. Although the exact causes of obesity have not been explained, studies in Pimas have found energy expenditure to be familial and a low metabolic rate to be predictive of subsequent weight gain. Detailed metabolic studies have not been conducted in other tribes, but a propensity to obesity and NIDDM is widespread, as has been the change from traditional high-carbohydrate diets to modern high-fat diets. Contemporary high-fat diets are associated with deterioration of carbohydrate metabolism in both Pimas and Caucasians[53]. Although our understanding of the current "epidemic" of NIDDM in Native Americans is based on studies of Pimas, the interaction between environmental changes and genetic susceptibility to NIDDM is not limited to Pimas but appears to be widespread in all indigenous North Americans, as well as other populations throughout the world.

MORTALITY

The mortality from diabetes in Native Americans is striking, yet it is seriously underestimated in U.S. vital statistics data. The figures published for diabetes death rates in 1986-88 showed the age-adjusted American Indian death rate was 2.7 times the rate for the general U.S. population[2]. These figures reflect only cases in which diabetes was the underlying cause of death, not those in which it was a contributing cause or those in which diabetes was not listed on the death certificate. Mortality rates by IHS Area are shown in Table 34.3. During 1984-86, there were 1,252 Native American deaths with diabetes listed as a contributing cause of death and 708 deaths with diabetes listed as the underlying cause[54]. In addition, the National Mortality Followback Study found that Native American heritage was underreported on death certificates by 65%[54]. When the 1986-88 relative mortality rates are adjusted for underreporting of heritage, the diabetes mortality for Native Americans is 4.3 times the rate for whites. In a New Mexico study, American Indians experienced 3.6 times the diabetes death rates of whites[55]. Over a 30-year period in New Mexico, diabetes death rates in American Indians increased 550% in women and 249% in men. A mortality study on Canadian Indian reserves in seven provinces found the risk of death from diabetes to be 2.2 times higher for native men and 4.1 times higher for native women than the rates for the Canadian population as a whole[56].

Detailed mortality studies in Pimas during 1975-84 found that the age- and sex-adjusted death rate from diabetes was 11.9 times greater than the 1980 death rate for all races in the United States[57]. Diabetic nephropathy was the leading cause of death in diabetic Pimas, followed by ischemic heart disease[58]. Longer duration of diabetes (Figure 34.7)[58] and proteinuria[59] were both associated with increased mortality. A 10-year followup of a cohort of diabetic Oklahoma Indians also showed striking death rates: 5% annually for men and 4% for women, which were three and four times the rates expected for men and women in the general Oklahoma population[60]. Circulatory disease

Table 34.3

Age-Adjusted Mortality Rates for Deaths Due to Diabetes, American Indian and Alaska Native Population, 1984-89

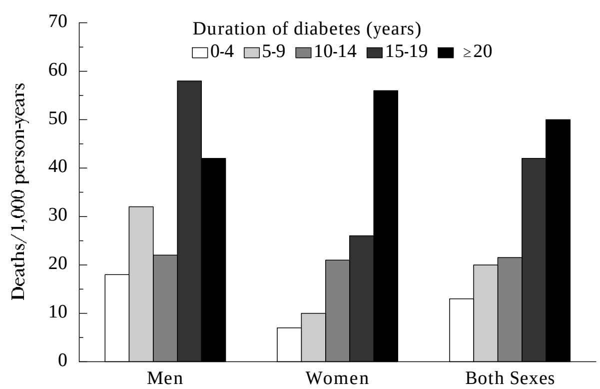
IHS Service Area	Rate per 100,000 population 1984-86	1985-87	1986-88	1987-89
Total	24.5	25.2	26.2	29.1
Aberdeen	44.7	41.3	35.6	50.1
Alaska	5.7	5.9	5.8	7.6
Albuquerque	25.0	32.4	33.1	32.8
Bemidji	32.9	29.4	28.6	39.0
Billings	24.8	27.8	23.6	40.1
California	10.4	15.2	15.5	15.3
Nashville	30.5	30.4	39.5	45.0
Navajo	21.2	23.8	23.6	27.4
Oklahoma	21.3	20.1	20.6	21.1
Phoenix	54.0	51.4	53.9	53.2
Portland	15.5	18.3	24.2	25.4
Tucson	52.9	59.0	69.6	68.1

Data are for populations residing in the IHS service areas and are age-adjusted to the 1940 U.S. Census; Alaska rates are based on <20 deaths.

Source: Indian Health Service Program statistics

Figure 34.7

Age-Adjusted Mortality of Pima Indians by Duration of Diabetes



Data are for deaths due to natural causes in diabetic individuals age ≥35 years.

Source: Reference 58

causes of death in this cohort exceeded those attributed to diabetes as the underlying cause. Although the contributions of diabetic renal disease and atherosclerotic heart disease to overall diabetes-related mortality vary among tribes, both clearly contribute to the very significant mortality from diabetes in North American Indian communities.

COMPLICATIONS

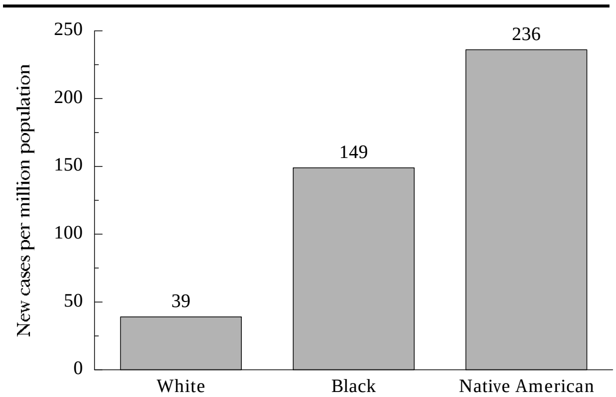
DIABETIC NEPHROPATHY

End-stage renal disease (ESRD) registries in the United States and Canada have documented that Native American populations are at high risk for entering treatment for kidney failure. During 1981-86, ESRD rates in Canadian Natives were 2.5 to 4 times the national rates, depending on the assumptions used to determine the native population[61]. One-fourth of the ESRD cases were attributed to diabetes. In the United States, the age-adjusted ESRD incidence for Native Americans during 1983-86 was 2.8 times the rate for whites, with 55% of Native American cases attributed to diabetes[62]. In 1987-90, the diabetic ESRD incidence for Native Americans was six times higher than the white rate (Figure 34.8)[63]. Reports from individual tribes confirm that high rates of diabetic renal failure occur in many tribes, including the Navajo, Cherokee, Alaska Native, Sioux, Pima, Zuni, Chippewa, and Oklahoma tribes[14,15,23,64-68]. In Pimas, diabetic nephropathy surpassed ischemic heart disease as the leading cause of nontraumatic death during 1975-84[58].

The natural history of diabetic kidney disease in Pimas has been well defined[69]. Both overt diabetic nephropathy and ESRD increase as the duration of diabetes increases[70]. High blood pressure and hyperglycemia predict the development of overt nephropathy. Similarly, fasting blood glucose and hypertension were found to be significant risk factors for the development of renal failure in Oklahoma Indians[68]. Diabetic offspring who have at least one parent with diabetes and proteinuria are at greater risk to develop nephropathy than diabetic offspring whose parents do not have proteinuria[71]. Studies of glomerular function in Pimas also showed that individuals with recent-onset NIDDM had higher glomerular filtration rates than nondiabetic Pimas[72]. Both clinical and epidemiologic studies have suggested that the natural history of diabetic nephropathy in Pimas is similar to diabetic nephropathy in individuals with IDDM (Figure 34.9)[66,73].

Figure 34.8

U.S. Incidence of Diabetic ESRD, 1987-90



ESRD, end-stage renal disease.

Source: Reference 63

DIABETIC RETINOPATHY

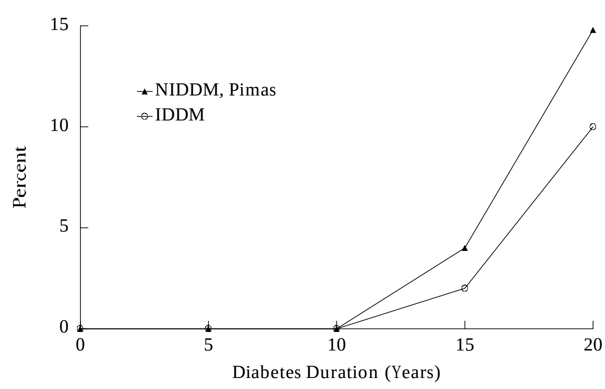
Diabetic retinopathy has been reported in many tribes[13,15,22,74-76]. Detailed studies of the incidence and risk factors for retinopathy have been reported for the Pima and several tribes of Oklahoma Indians[77-83]. Rates of retinopathy and risk factors are summarized in Table 34.4. An association of insulin therapy with diabetic retinopathy similar to that found in U.S. studies has also been found in Native Americans in Canada[84].

LOWER EXTREMITY AMPUTATION

Lower extremity amputation (LEA) rates are unfortunately high in many tribes, although the rates in small

Figure 34.9

Cumulative Incidence of Diabetic ESRD in Pima Indians with NIDDM and in Individuals with IDDM



ESRD, end-stage renal disease.

Source: References 66 and 73

Table 34.4
Diabetic Retinopathy in American Indians

Ref.	Group	Retinopathy (%)	Risk factors
Retinopathy Prevalence			
79	Oklahoma	24.4	Hyperglycemia
75	Oklahoma	49.3	Hypertension
80,82	Pima	18	Duration of diabetes Insulin therapy
Retinopathy Incidence			
81	Oklahoma	72.3	
Proliferative Retinopathy Incidence			
83	Oklahoma (mean 12.7 years followup)	18.5	Hyperglycemia Duration of diabetes Cholesterol Systolic blood pressure Insulin therapy
82	Pima (after 20 years followup)	14	Young age at diagnosis Duration of diabetes Background retinopathy Hypertension Proteinuria Renal insufficiency Neuropathy Cholesterol Insulin therapy

Source: References are listed within the table

studies vary among reservations[13-15,22,23]. During 1982-87, Navajos experienced hospital discharge rates of 74 per 10,000 for LEA, compared with 240 per 10,000 for the Indians of southern Arizona[85]. Ten percent of identified diabetic patients in southern Arizona had a recorded history of LEA on their medical records in 1985-86[6]. Several studies have reported higher LEA rates in males than in females[6,76,85-87]. Duration of diabetes has been reported as a significant risk factor for LEA in several tribes[86,87]. Prospective data on risk of foot ulceration and LEA in Chippewa Indians showed 9.9 times higher foot ulceration rates and 17 times higher amputation rates in diabetic patients without protective sensation, compared with patients who retained the ability to perceive the 5.07 Semmes-Weinstein monofilament[88]. Of 358 diabetic individuals, 7.7% had severe peripheral neuropathy as evidenced by lack of sensitivity to the 5.07 monofilament.

Rates of first LEA in retrospective studies were 13.7 per 1,000 diabetic person-years in Pima Indians (1972-84) and 18 per 1,000 in Oklahoma Indians (1972-80)[86,87]. Hyperglycemia, retinopathy, nephropathy, and signs of neuropathy including medial artery calcification were predictive risk factors for LEA in Pimas[86]. Although amputation rates in Pimas increased with age, the effect of age was not significant after controlling for duration of diabetes. Similar risk factors were reported for first LEA in Oklahoma Indians, although no indicators of neuropathy were reported[87]. Five-year survival after amputation was 40% in Oklahoma Indians and 61% in Pimas[86,87]. Hypertension was a significant risk factor in the Oklahoma tribes but not in the Pima. These variations suggest that peripheral vascular disease and neuropathy may differ significantly among tribes in their contribution to LEA.

PERIODONTAL DISEASE

Periodontal disease rates in Pima Indians were 2.6 times higher in diabetic patients than in nondiabetic individuals[89]. Destructive periodontal disease was also more severe in diabetic individuals[90]. The frequency of edentulousness increased markedly with diabetes duration[91]. At 20 years duration, 75% of diabetic Pimas were edentulous. The presence of retinopathy and poor glycemic control were associated with an increased risk of periodontal disease.

INFECTIONS

Although the pathogenesis of infections as complications of diabetes is not simple, it is clear that infections are of particular importance in Native Americans. Tuberculosis mortality in American Indians in 1987 was 5.8 times higher than the rate for all races in the United States[2]. A case-control study in Sioux Indians showed that diabetic individuals were 4.4 times more likely to develop tuberculosis than nondiabetic individuals[92]. Mortality from infectious diseases in Pimas is significant[57]. Although overall infectious disease mortality rates did not differ between diabetic and nondiabetic Pimas during 1975-84, the number of deaths studied was small[58]. Five of the six deaths from coccidioidomycosis, a disease endemic in the Southwest, occurred in diabetic patients. Similarly, 81% of the 26 cases of necrotizing fasciitis, a rare but severe soft-tissue infection, reported from the Phoenix Indian Medical Center during a 9-year period occurred in diabetic patients[93]. Thus, infections associated with diabetes in Native Americans are of particular concern. Unfortunately, detailed epidemiologic data on the particular associations are lacking for most tribes.

GALLBLADDER DISEASE

Gallbladder disease and diabetes have been linked together in Native Americans as part of a "New World syndrome" with both a genetic and evolutionary basis[94]. In an analysis of gallbladder disease in Pimas during a 20-year period, no excess risk of death was found in diabetic individuals with gallstones compared with individuals with normal glucose tolerance and gallstones[95]. However, Pimas with gallstones experienced both increased mortality from gallbladder cancer and total mortality from other causes. Overall cancer mortality, however, was not significantly different between diabetic and nondiabetic Pimas[58].

CATARACTS

The incidence of visually disabling cataracts as estimated by first cataract surgery was higher in Pimas, compared with the U.S. population as a whole[96]. After controlling for age and sex, diabetic individuals experienced more than twice the rate of cataract extraction than nondiabetic individuals. Cataract surgery rates increased with longer duration of diabetes and in those treated with insulin.

CARDIOVASCULAR DISEASE

Although our understanding of the epidemiology of cardiovascular disease is incomplete, studies of specific tribes clearly suggest that diabetes is a major risk factor for cardiovascular disease in all Native American populations.

ISCHEMIC HEART DISEASE

Our understanding of cardiovascular disease in Native Americans and its relationship to diabetes and other risk factors is evolving. Rates of ischemic heart disease have changed markedly in recent years, and both the rates and the relative contribution of known risk factors appear to vary among tribes[97]. Ischemic heart disease and stroke rates in Canadian Indians have equaled or exceeded Canadian national rates in recent years, sparing only the more isolated and less acculturated communities[98]. In Pima Indians, a tribe with low coronary heart disease rates, diabetes is a major risk factor for coronary artery disease[99]. All fatal coronary events in Pimas during 1975-84 occurred in diabetic individuals. Reports from many tribes describe myocardial infarction or ischemic heart disease in association with diabetes[13,15,23,100-103]. The Strong Heart Study of diabetic and nondiabetic American Indians age 45-74 years in Arizona, Oklahoma, and North and South Dakota was designed to quantify cardiovascular morbidity and mortality and to compare risk factors among tribes[104]. Major electrocardiogram (ECG) abnormalities were significantly higher in diabetic individuals in all tribes, with the association greatest in Arizona, where cardiovascular disease rates were lowest[105].

The interactions among diabetes and its risk factors and cardiovascular disease are complex and have been studied in detail only in Pimas, where the influence of hyperinsulinemia, insulin therapy, insulin resistance, and hypertension have been examined[106]. In this tribe, neither endogenous hyperinsulinemia nor exogenonous insulin therapy was prospectively associated with ECG abnormalities. In addition, mean blood pressure was not correlated with insulin resistance[107]. Diabetes and insulin resistance, however, were associated with increased levels of very low-density lipoproteins and decreased high-density lipoproteins[108]. In a preliminary report from the Strong Heart Study, rates of hypercholesterolemia varied among different tribes[104]. The WHO study of vascular disease in diabetes also found higher mean cholesterol values in Oklahoma Indians than in Pimas[103]. The relative influences of diabetes and insulin resistance on cardiovascular disease remain unknown.

HYPERTENSION

From the limited data available, hypertension in Native Americans in the United States appears to be less prevalent than in the general U.S. population[105,109]. In Canada, however, a sample of Canadian Indians had higher diastolic blood pressures than the overall Canadian population[99]. Diabetes and hypertension coexist at varying rates in the United States[109]. The relative risk of diagnosed hypertension in diabetic patients compared with nondiabetic individuals ranges from 4.7 to 7.7 in different IHS regions; overall, 37% of ambulatory diabetic patients had diagnosed hypertension. Hypertension in diabetic individuals has been reported in 46.5% of Navajos, 53% of Cherokees, and 48.6% of Canadian Cree and Ojibwa tribes[22,110,111].

STROKE

There is a paucity of published data on stroke rates in diabetic Indians. In Pima Indians, stroke-related mortality did not differ between diabetic individuals and those with normal glucose tolerance; however, the number of stroke events was small[58]. In diabetic Alaska Natives, rates of stroke were similar to rates found in a white diabetic population[23].

DIABETES ANTEDATING PREGNANCY

The short- and long-term interactions of diabetes and pregnancy are of major concern for both mother and offspring in Indian communities. Although IDDM is rare in North American Indians, young Pima women with NIDDM antedating pregnancy experienced the same pattern of congenital abnormalities described in pregnancies complicated by IDDM[112]. Diabetes antedated pregnancy in 7 (1%) of 591 Zuni Indian women during 1989-90, and in 38 (2%) of 1,854 Tohono O'odham women during 1984-88[113,114]. In the latter group, gestational diabetes was diagnosed before the 20th week of pregnancy in 25 (42%) of 59 of the gestational diabetic pregnancies, suggesting that diabetes may also have antedated pregnancy in these cases. Preexisting diabetes occurred in 13 (0.3%) of 4,094 Navajo women who delivered during 1983-87 in IHS facilities on the Navajo Reservation[115]. For Pima women, a diagnosis of diabetes antedating pregnancy was associated with increased rates of perinatal mortality, large-for-gestational-age births, toxemia, and Caesarian section, compared with women with normal glucose tolerance[116].

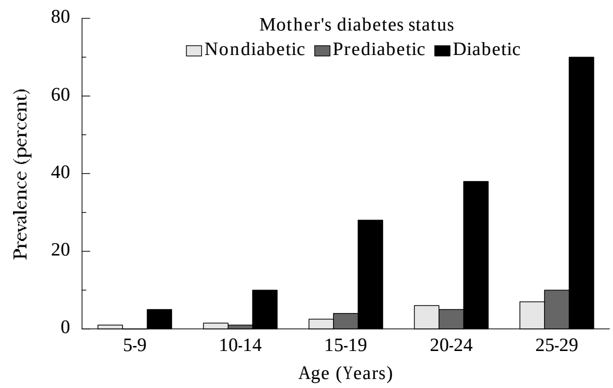
GESTATIONAL DIABETES

Gestational diabetes mellitus (GDM) diagnosed according to O'Sullivan and Mahan criteria has been reported in many tribes with varying rates. For example, 14.5% of pregnancies in Zuni, 3.4% of deliveries in Navajo, and 5.8% of deliveries in Yupik Eskimo women were in women with GDM[113,115,117,118]. Impaired glucose tolerance during pregnancy diagnosed in Pima Indians by WHO criteria was associated with rates of fetal and maternal complications that were intermediate between the rates experienced by normal and overtly diabetic women[25,113,119]. Follow-up studies of American Indian women with a history of abnormal glucose tolerance during pregnancy found high risks of developing subsequent overt diabetes: 27.5% of Pima women developed diabetes within 4-8 years and 30% of Zuni women with GDM developed diabetes within 0.5-9 years[113,119].

The longitudinal studies of diabetes in the Pima community have revealed striking associations of diabetic pregnancy with obesity and diabetes in the offspring[120-123]. By age 20-24 years, offspring of a diabetic pregnancy had a higher rate of diabetes (45%) than offspring of prediabetic women (8.6%) or nondiabetic women (1.4%) (Figure 34.10)[121]. Fasting hyperinsulinemia, obesity, and abnormal glucose tolerance occurred at an earlier age in offspring of women with abnormal glucose tolerance, compared with offspring exposed to normal glucose levels *in utero*[121,122].

Figure 34.10

Prevalence of Diabetes in Pima Offspring by Age and Maternal Diabetes Status



Diabetes defined by 2-hour post-challenge glucose ≥200 mg/dl.

Source: Reference 121

Because of the longitudinal nature of the Pima studies, these data are unique. However, the widespread emergence of NIDDM in Native American children has been noted in both the United States and Canada, suggesting that the interactions of diabetes and pregnancy, which are well described in Pima Indians, are probably not limited to one tribe but pose major public health challenges in many North American indigenous communities[124,125].

HEALTH CARE DELIVERY AND PREVENTION

PREVENTIVE HEALTH SERVICES

The magnitude and scope of health problems related to diabetes in American Indian communities have evoked changes in the health care systems that were originally designed primarily to prevent symptomatic infectious disease and to promote maternal and child health[126]. Efforts to organize consistent preventive health services for diabetic patients and to evaluate patient outcomes in the primary health care setting have used public health techniques such as surveillance and registries[88,127-133]. Programs of high-quality diabetes care have been organized in rural, isolated Native American communities[127,128,133]. These programs incorporate unique features, with each program designed specifically to promote the involvement of the community it serves. The importance of Native American community involvement in the implementation of practice guidelines was specifically noted by the Expert Committee of the Canadian Diabetes Advisory Board[134]. Today, preventive health care programs in Native American communities combine the strategies successfully used in the past for infectious diseases with the newer diabetes care guidelines. In some cases these preventive strategies overlap. Because of the high risk of the reactivation of tuberculosis in diabetic individuals, the IHS has recommended systematic tuberculosis prophylaxis for diabetic American Indian patients[92]. Effective intervention strategies continue to be studied in the United States and Canada.

EDUCATION

Just as diabetes clinical guidelines have been adapted for the needs of Native American Indians with diabetes, educational programs and materials have also been developed and evaluated systematically to target these cultures[135-137]. Nutrition education has emphasized single-concept messages rather than conventional dietary exchange systems[137]. Diabetes education programs that involve the community have evolved by using a stepwise approach to implementing national diabetes education standards[138]. Native American interpreters trained in diabetes terminology have become crucial to the success of diabetes education in cross-cultural settings[139]. Diabetes training for community health representatives and Alaska village health aides has been organized to promote effective preventive care and education from within the community by mobilizing community health workers.

PRIMARY PREVENTION

Both the historical experience of Native American communities and the growing understanding of the pathophysiologic interactions between genetics and lifestyle suggest that NIDDM can be prevented in Native Americans. In response to the growing burden of diabetes, communities have organized health promotion efforts to increase fitness and decrease obesity[140]. For example, the Pueblo of Zuni has maintained a community-based prevention program for more than 10 years[141,142]. Metabolic control improved in the program's diabetic patients who exercised, compared with patients who did not[143]. A recent retrospective study in Zuni found that even after adjusting for obesity, the odds of presenting with diabetes decreased with increasing exercise frequency in this high-risk community[47]. Diabetes prevention efforts have spread to many Native American communities. These efforts include the revival of traditional physical activities and native foods to promote a healthy lifestyle[140]. Formal clinical trials to test the feasibility of preventing NIDDM will be of major significance to these communities.

PSYCHOSOCIAL AND CULTURAL STUDIES

The growing burden of diabetes in Native Americans has stimulated communities and investigators to ex-

Table 34.5
Psychosocial and Cultural Studies of Diabetes in Native Americans

Books

Diabetes and Native Americans: The impact of lifestyle and cultural changes on the health of indigenous peoples. Joe J, Young R, eds. Moulton Press, Berlin, 1994

Monographs

Diabetes in Canadian native population: Biocultural perspectives. Young TK, ed. Canadian Diabetes Association, 1987

Pine CJ: *Diabetes and behavior: American Indian issues*. American Indian and Alaska Native Mental Health Research. Monograph 1:94-115, 1988

Rokala DA, Bruce SG, Meiklejohn C: *Diabetes mellitus in native populations of North America: An annotated bibliography*. Monograph, Series No. 4. Northern Health Research Unit, Department of Community Health Services. University of Manitoba, Winnipeg, 1991

Articles

Camazine SM: Traditional and western health care among the Zuni Indians of New Mexico. *Soc Sci Med* 14B:73-80, 1980

Hagey R: The phenomenon, the explanations and the responses: Metaphors surrounding diabetes in urban Canadian Indians. *Soc Sci Med* 18:265-72, 1984

Huttlinger K, Krefting L, Drevdahl D, Tree P, Baca E, Benally A: "Doing battle": A metaphorical analysis of diabetes mellitus among Navajo people. *Am J Occup Ther* 46:706-812, 1992

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Miller P, Wikoff R, Keen O, Norton J: Health beliefs and regimen adherence of the American Indian diabetic. *American Indian and Alaska Native Mental Health Research* 1:24-36, 1987

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Womack RB: Measuring the attitudes and beliefs of American Indian patients with diabetes. *Diabetes Educator* 19:205-09, 1993 amine traditional and modern perspectives on diabetes. Several anthropologic studies have documented the interpretations of Native Americans affected by diabetes regarding the etiology of the disease, the experience of illness, and the efficacy of treatment. Native American communities perceive diabetes as a new disease that has come from the outside. If approaches to diabetes in both individuals and communities are to be effective, these efforts require appropriate cultural adaption to local health beliefs. Selected references from the growing number of studies are presented in Table 34.5. These studies are the foundation for the important cultural understandings that must develop along with the scientific framework to enable Native Americans to control the diabetes epidemic.

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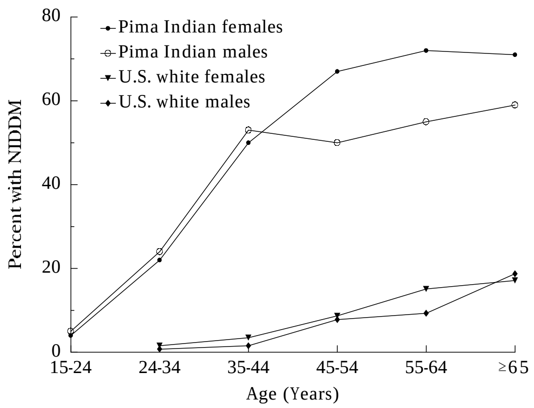
Appendix 34.1
Age-Specific Prevalence of NIDDM in Pima Indians and U.S. Whites



Diabetes includes both diagnosed and undiagnosed cases by World Health Organization criteria.

Source: Pima data for 1974-82 (Reference 27); U.S. data are from the 1976-80 Second National Health and Nutrition Examination Survey

Appendix 34.2
Values for Metabolic Variables in American Indian Diabetic Subjects in the Strong Heart Study, Age 45-64 Years

	Arizona		Oklahoma		South Dakota/North Dakota	
	Men	Women	Men	Women	Men	Women
Previously Diagnosed Diabetes						
Mean fasting plasma glucose (mg/dl)	221.1	242.6	197.4	211.9	210.9	225.4
Mean 2-hour plasma glucose (mg/dl)	341.9	356.1	298.6	247.4	297.1	275.8
Mean fasting insulin (μu/ml)	23.5	29.7	24.1	29.4	21.6	26.5
Mean number of years since diagnosis of diabetes	13.0	14.0	9.0	10.8	7.9	9.0
Newly Discovered Diabetes						
Mean fasting plasma glucose (mg/dl)	154.0	164.7	168.5	156.2	149.7	149.5
Mean 2-hour plasma glucose (mg/dl)	257.1	287.8	254.9	256.2	256.0	262.5
Mean fasting insulin (μu/ml)	30.0	32.3	29.0	29.6	26.5	27.2
All Diabetes Combined						
Percent with self-reported history of diabetes in mother and/or father	62.3	63.1	47.0	61.7	52.2	48.9
Mean BMI	31.2	33.4	32.7	33.7	30.7	31.9
Percent with BMI ≥25	85.2	89.1	93.4	94.5	90.0	90.6
Percent with BMI ≥30	48.4	66.1	64.7	71.0	56.3	60.6
Percent with BMI ≥35	20.1	35.8	28.7	40.3	12.5	26.0
Mean waist/hip ratio	0.97	0.96	0.98	0.94	1.01	0.96
Mean systolic blood pressure (mmHg)	131.2	131.0	134.8	130.0	127.5	122.8
Mean diastolic blood pressure (mmHg)	81.6	76.6	83.3	76.9	80.3	74.8
Percent with hypertension	39.4	32.4	41.9	41.2	25.6	24.2

Appendix 34.2—Continued next page

Appendix 34.2—Continued

	Arizona		Oklahoma		South Dakota/North Dakota	
	Men	Women	Men	Women	Men	Women
All Diabetes Combined						
Mean total cholesterol (mg/dl)	181.1	184.1	190.7	197.2	203.9	203.9
Mean LDL cholesterol (mg/dl)	100.4	105.6	115.5	115.5	118.2	118.7
Mean HDL cholesterol (mg/dl)	43.0	43.7	38.9	44.4	37.8	43.6
Mean fasting triglycerides (mg/dl)	190.5	173.5	179.9	179.4	224.7	197.6
Percent with total cholesterol ≥240 mg/dl	6.7	10.7	5.4	12.2	16.9	15.0
Percent with LDL cholesterol ≥160 mg/dl	2.8	5.9	9.6	7.1	8.1	9.1
Percent with HDL cholesterol <35mg/dl	29.3	20.7	39.5	16.4	34.4	21.7
Percent with triglycerides ≥250 mg/dl	16.6	15.7	18.0	16.8	23.1	21.5

Hypertension defined as systolic blood pressure ≥160 mmHg or diastolic blood pressure ≥95 mmHg or using antihypertensive medication; values for blood pressure includes values for subjects on antihypertensive medications. American Indian tribes are: Arizona—Pima, Maricopa; Oklahoma—The Seven Tribes (Apache, Caddo, Comanche, Delaware, Fort Sill Apache, Kiowa, Wichita); North Dakota/South Dakota—Oglala Sioux, Cheyenne River Sioux, Devil's Lake Sioux.

Source: Elisa Lee, University of Oklahoma, Strong Heart Study