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Serum Cholesterol Concentrations Among Navajo Indians

JONATHAN R. SUGARMAN, MD, MPH
TIMOTHY J. GILBERT, RD, MPH
CHRISTOPHER A. PERCY, MD
DOUGLAS G. PETER, MD

Dr. Sugarman is Deputy Senior Epidemiologist, Indian Health Service (IHS), in Seattle, WA. Mr. Gilbert is Public Health Nutritionist, Health Promotion/Disease Prevention Program, and Dr. Percy is Director, Community Health Services, Shiprock Public Health Service Hospital, Shiprock, NM. Dr. Peter is Chief Medical Officer for the Navajo Area, IHS, Window Rock, AZ.

Glenn Tso, Treva McKinley, Laria Benally, Roselyn O'Donnell, MLT, and William Tool, MLT, of the Shiprock PHS Laboratory staff were among those who obtained the serums and performed the chemistry analyses.

The study was presented in part at the annual meeting of the American Public Health Association, New York, NY, Sept. 30—Oct. 4, 1990. The research was supported in part by IHS grant 89-13.

Tearsheet requests to Jonathan R. Sugarman, MD, MPH; IHS, 2201 Sixth Ave., Room 300, Seattle, WA 98121.

Synopsis

Navajo Indians have been reported by earlier investigators to have low concentrations of serum lipids and a low prevalence of hyperlipidemia, as well as low rates of ischemic heart disease. However, no data on serum lipid concentrations among Navajos have been reported for more than two decades. The authors conducted a study to determine the distribution of concentrations of serum total cholesterol (TC), high density lipoprotein cholesterol, low density lipoprotein cholesterol, and triglyceride among persons 25-74 years old living in a representative community on the Navajo Indian reservation. Data are reported for 255 subjects, 105 men and 150 women, ages 25-74 years. The authors compared these data to those for the general population as determined by the second National Health and Nutrition Examination Survey (NHANES II).

TC concentrations among Navajo men were similar to those from NHANES II. TC concentrations among younger Navajo women were similar to those for women younger than 55 years from NHANES II, but were significantly lower among older Navajo women. While 27.6 percent of men ages 25-74 years studied in NHANES II had TC concentrations greater than 240 milligrams per deciliter, 33.8 percent of Navajo men had similarly elevated TC. However, the prevalence of serum TC concentrations greater than 240 milligrams per deciliter among Navajo women (17.5 percent) was about half that among women studied in NHANES II (32.9 percent). A similar pattern was found for low density lipoprotein cholesterol.

The researchers concluded that Navajo Indians are no longer characterized by low serum lipid

concentrations, that increased cholesterol concentrations may be a harbinger of increasing rates of atherosclerotic coronary heart disease among Navajos, and that attention should be directed to primary prevention of hyperlipidemia in Navajo Indian communities.

THE PREVALENCE of atherosclerotic coronary heart disease among Navajo Indians, the largest Indian tribe in the United States, has been reported to be substantially lower than that among the general population, and among the lowest of Indian people in the United States (*1*). Until the 1970s, myocardial infarctions among Navajos were reportedly rare events (*2, 3*).

Relatively low rates of coronary heart disease among Navajos were attributed by earlier investigators to low rates of cardiovascular risk factors, including smoking, elevated serum cholesterol concentrations, obesity, sedentary life style, diabetes mellitus, and hypertension (*3, 4*).

In contrast to the low prevalence of these cardiovascular risk factors among Navajos in the past, however, Navajos currently suffer from high rates of noninsulin-dependent diabetes mellitus (NIDDM) and obesity (*5, 6*) and increasing rates of hypertension (*7, 8*). Although tobacco use remains low, it appears to be increasing, especially among youth (unpublished data from Steven Helgerson, MD, MPH, Navajo Adolescent Health Survey, Indian Health Service, 1988).

Although data are lacking, many believe that the lifestyle of contemporary Navajos is considerably more sedentary than their lifestyle as recently as the 1960s (*9*). The increasing prevalence of risk factors has been accompanied by large (243 percent among men and 496 percent among women) increases in the incidence of diagnosed myocardial infarctions among Navajos from the 1984–86 period, compared with 1976–79 (*10*).

Despite recent observations regarding the increased prevalence of other cardiovascular risk factors, the distribution of serum lipid concentrations among Navajo Indians has not been examined for more than two decades. Although earlier investigators consistently reported that serum cholesterol concentrations among Navajos were lower than those among the general population, and hypercholesterolemia was reported to be uncommon (*4, 11, 12*), many Indian Health Service (IHS) clinicians believe that high serum cholesterol concentrations among Navajos are no longer uncommon.

In order to estimate the distribution of concentrations of serum total cholesterol (TC), low density lipoprotein (LDL) cholesterol, high density lipoprotein (HDL) cholesterol, and triglyceride (TG) among adult Navajo Indians, we examined 255 adults residing in a representative Navajo community and compared the results with data reported for the general population.

Methods

Subjects. About 200,000 Navajo Indians reside on the 25,000 square-mile Navajo Reservation located in northeast Arizona, southeast Utah, and northwest New Mexico. The Navajo Nation includes 109 governmental subdivisions known as chapters. We conducted our study in the Teec Nos Pos Chapter, a 360-square mile area in northeast Arizona near the Four Corners area of New Mexico, Arizona, Utah, and Colorado. Residents of the community follow lifestyles ranging from those based on traditional religious practices and occupations, such as sheepherding, to more acculturated modes of life, characterized by modern housing and work for wages.

The study population has been described (*13, 14*). Briefly, between April 1, 1986, and March 31, 1987, a community-based screening study to estimate the prevalence of NIDDM was conducted using a house-to-house survey, supplemented by screening in public places, such as trading posts and post offices, and a local IHS clinic. In that survey (here designated S-1), 494 persons (about 76 percent of the adult population estimated by extrapolation of the 1980 census) 20 years and older were evaluated.

Between February 23, 1989, and February 1, 1990, efforts were made to invite each member of the cohort studied in S-1 to participate in a second survey designed to further define NIDDM prevalence, and to estimate the incidence. The data presented in this report were collected in the second survey (later designated S-2). Based on a comparison of age, capillary blood glucose, and body mass index during S-1, respondents and nonrespondents for S-2 were similar, although body mass index was slightly greater among respondents (*14*).

Subjects who agreed to participate in S-2 were examined in their homes or in a local IHS clinic using the protocol described. Data are reported for 255 subjects, 105 men and 150 women, ages 25–74

Table 1. Anthropometric characteristics of 255 Navajo subjects, by age groups, Teec Nos Pos Chapter, Arizona, 1990

Age range (years)	Number subjects	BMI [1] (mean + SEM [2])	BMI [1] range	Waist-hip ratio	Subscapular skinfold thickness [3] (mean + SEM [2])	Triceps skinfold thickness [3] (mean + SEM [2])
Men						
25–34	20	28.2 ± 0.9	22.4–36.3	0.97 ± 1.6	27.5 ± 1.6	22.2 ± 1.4
35–44	28	30.4 ± 1.1	20.5–48.7	0.99 ± 0.01	30.1 ± 1.7	22.7 ± 1.9
45–54	21	28.5 ± 1.1	20.9–38.1	1.01 ± 0.02	25.7 ± 2.4	18.3 ± 1.8
55–64	18	28.1 ± 0.7	22.5–34.2	1.01 ± 0.01	24.4 ± 1.8	17.9 ± 1.5
65–74	18	26.5 ± 0.7	20.3–31.6	0.98 ± 0.02	21.5 ± 1.7	15.6 ± 1.3
Women						
25–34	37	29.3 ± 1.2	18.7–56.8	0.89 ± 0.02	32.6 ± 1.5	26.5 ± 1.1
35–44	32	30.2 ± 1.1	23.1–46.8	0.92 ± 0.02	34.5 ± 1.3	29.1 ± 1.4
45–54	34	30.3 ± 1.0	24.4–60.1	0.91 ± 0.4	31.7 ± 1.2	28.8 ± 0.9
55–64	31	30.9 ± 1.2	20.0–46.1	0.91 ± 0.03	31.0 ± 1.7	25.8 ± 1.3
65–74	16	30.7 ± 1.5	20.0–42.1	0.90 ± 0.02	28.4 ± 3.0	25.3 ± 2.0

[1] Body mass index, calculated as weight (kg) divided by height (m^2). [2] SEM = standard error of mean. [3] In millimeters.

years. The subjects included 64 percent of the living subjects within the same age groups who were examined during S-1, and represent about 47 percent of the estimated adult population of similar age in Teec Nos Pos Chapter. The age distribution of subjects was similar to that of adults living in the community, except that residents in the 25–34-year age groups were slightly underrepresented in the study cohort.

Subjects were instructed to fast for at least 10 hours prior to the morning of the examination. Those who admitted to noncompliance with this instruction were rescheduled. Subjects were weighed to the nearest 100 grams on an electronic scale (*A*) in light clothing without shoes.

Height was obtained to the nearest 0.5 centimeter using a height board (*B*). The triceps skinfold thickness was measured as a vertical fold over the belly of the triceps halfway between the acromion and olecranon processes. The subscapular skinfold thickness was measured using a diagonal fold just under the lower angle of the scapula, halfway between the spine and the side of the body. All skinfold measurements were obtained on the right side of the body using Lange skinfold calipers (*C*). The mean of three measurements for each skinfold was recorded to the nearest millimeter. The waist and hip circumferences were measured at the iliac crest and at the maximum extension of the buttocks, respectively. While the subject was seated, a venous blood sample was collected for determination of plasma glucose and serum lipids. Nondiabetic subjects were administered a 75 gram oral glucose tolerance test. Diabetes was diagnosed according to World Health Organization criteria (*15*).

The protocol for the study was approved by the local elected Health Board and the regional and national institutional review boards of IHS. Written informed consent was obtained from all subjects. The results of the cholesterol and glucose determinations were communicated to each study subject.

Lipid analyses. Venipuncture samples for lipid level determinations were collected in serum separator tubes (*D*), allowed to clot, and were centrifuged at 1,000 g for 15 minutes. The serum was separated and refrigerated until transportation to the Shiprock Public Health Service Hospital. When lipid assays were not performed on the day of collection, serum was frozen at minus 70 degrees C.

Within 1 week, TC, HDL, and TG levels were measured enzymatically using an ACA II autoanalyzer (*E*), an instrument that has been reported to provide cholesterol and triglyceride measurements within acceptable ranges of precision and bias established by the National Cholesterol Education Program (*16, 17*). In order to establish comparability of measurements with the Centers for Disease Control's Abell-Kendall reference method, duplicate aliquots of samples (110 for TC, 96 for HDL, and 110 for TG) measured on the ACA II were regularly forwarded to a reference laboratory (Pathlab, El Paso, TX) for assay using a SMAC autoanalyzer (*F*) calibrated to the CDC reference.

The average bias was determined by subtracting the mean of the patients' samples run on the ACA II from the mean of the samples determined in the reference laboratory, and dividing the difference by the mean of the samples from the reference laboratory. The average bias was 0.9 percent for TC, minus 5.0 percent for HDL, and 6.5 percent for

TG. When 4 TG levels of greater than 400 milligrams per deciliter (mg per dl) were excluded, the bias for TG fell to 5.4 percent.

Lyphochek levels 1 and 2 chemistry control, an unassayed, bovine serum-based lyophilized product (*G*), was used to establish coefficients of variation for the lipid assays. The coefficients of variation were 2.4 percent for TC, 5.3 percent for HDL, and 3.2 percent for TG for level 1. The coefficients of variation for level 2 were 3.5 percent for TC, 4.5 percent for HDL, and 5.0 percent for TG.

LDL levels were estimated using the Friedewald formula (LDL = TC minus HDL minus [TG divided by 5]) for subjects with TG levels of less than 400 mg per dl (*18*). Lipid analyses were compared to those for the general population during the second National Health and Nutrition Examination Survey (NHANES II) conducted from 1976 to 1980 (*19, 20*).

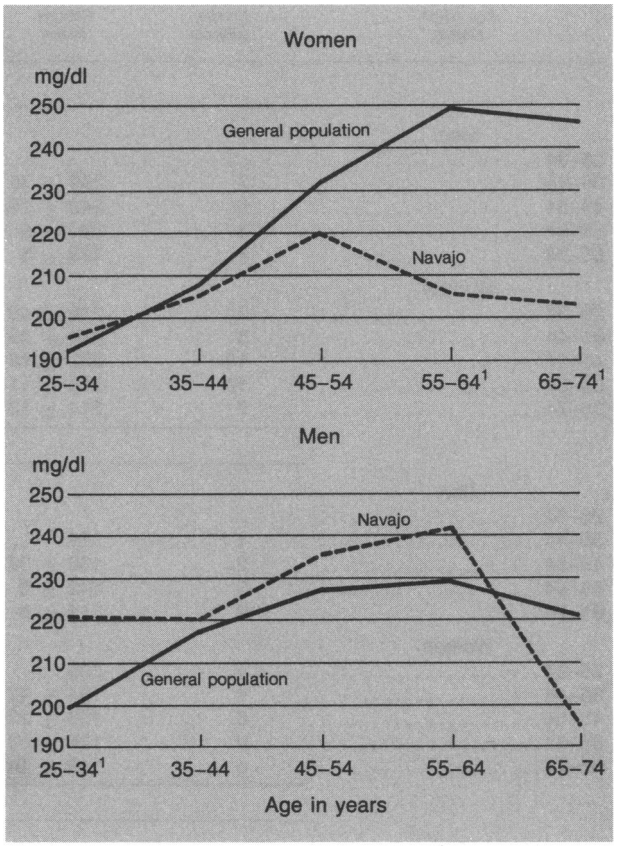
Statistical analyses. Descriptive statistics were calculated using a computer statistical analysis program, SPSS-PC (*21*). Differences between means were evaluated using Student's t-test. In order to improve skewness and kurtosis, a natural logarithmic transformation was used in conducting t-tests with TG levels. To account for multiple comparisons when t-tests were performed comparing differences between variables for each of the five age groups selected, a *P* value of less than 0.01 was required before a difference was considered to be significant. Proportions of subjects with high serum TC were age-adjusted by the direct method, using the 1980 general population as the reference (*22*).

Results

Anthropometric characteristics (weight, body mass index, waist-hip ratios, and triceps and subscapular skinfold thickness) are shown in table 1. There is a high prevalence of obesity in the population studied, and the high mean waist-hip ratios suggest that the pattern of obesity conforms to the centralized (rather than peripheral) distribution that characterizes other Indian populations (*23, 24*).

Mean serum TC, LDL, HDL, and TG concentrations among Navajos are shown by age, sex, and diabetes status in table 2. Among the entire cohort (diabetic and nondiabetic combined), in all but the oldest age group (ages 65–74 years), mean TC and LDL were lower among women than among men, although the differences are significant only for the 25–34-year and 55–64-year age groups.

Figure 1. Mean serum total cholesterol concentrations among 255 Navajo women and men, by age groups 25–74 years, Teec Nos Pos Chapter, Arizona, 1990, and among the general population, 1976–80



[1] $P < 0.01$.

NOTE: U.S. general population, all races, NHANES II. mg/dl = milligrams per deciliter.

Results were similar when diabetic subjects were excluded from the analyses. The numbers of diabetic subjects were too low to allow for meaningful comparisons within age groups. Among the total study cohort, mean serum TG concentrations were lower among women than among men in all age groups, although the differences were not statistically significant.

Mean TC concentrations among Navajos compared to the general population studied in NHANES II are shown by age and sex in figure 1. Mean TC among Navajo men was not significantly different from that among men in the general population 35 years and older, although it was slightly higher among Navajos in the 25–34-year age group. Mean TC among men in both cohorts tended to increase until the 55–64-year age group, after which the mean concentrations fell. Although mean TC concentrations among Navajo women were similar to those among women in the general population until the 45–54-year age group, the

Table 2. Mean concentrations [1] of lipoprotein cholesterol and triglyceride [2] among 255 Navajos, Teec Nos Pos Chapter, Arizona, by diabetic status, 1989–90

Age range (years)	Diabetic		Nondiabetic		Total	
	Number subjects	Concentration	Number subjects	Concentration	Number subjects	Concentration
			Total cholesterol			
Men						
25–34	...	...	20	221 ± 11	20	221 ± 11
35–44	2	259 ± 70	26	217 ± 9	28	220 ± 9
45–54	6	240 ± 18	15	233 ± 12	21	235 ± 10
55–64	6	224 ± 8	12	250 ± 15	18	242 ± 11
65–74	6	199 ± 8	12	192 ± 10	18	195 ± 7
Women						
25–34	2	216 ± 40	35	194 ± 4	37	195 ± 4
35–44	5	210 ± 25	27	204 ± 8	32	205 ± 7
45–54	10	235 ± 16	24	213 ± 8	34	220 ± 8
55–64	14	205 ± 11	17	205 ± 8	31	205 ± 6
65–74	7	214 ± 13	9	195 ± 19	16	203 ± 12
			LDL cholesterol[3]			
Men						
25–34	...	...	15	144 ± 10	15	144 ± 10
35–44	1	114	21	143 ± 7	22	142 ± 7
45–54	2	136 ± 33	12	144 ± 13	14	143 ± 11
55–64	3	142 ± 8	12	166 ± 14	15	161 ± 11
65–74	6	114 ± 8	9	108 ± 10	15	110 ± 7
Women						
25–34	1	105	30	111 ± 4	31	110 ± 3
35–44	4	104 ± 22	22	127 ± 9	26	124 ± 8
45–54	6	136 ± 23	20	128 ± 7	26	130 ± 7
55–64	9	118 ± 13	17	120 ± 7	26	119 ± 6
65–74	5	116 ± 14	4	107 ± 28	9	112 ± 14
			HDL cholesterol			
Men						
25–34	...	...	17	47 ± 3	17	47 ± 3
35–44	1	46	23	51 ± 5	24	51 ± 5
45–54	4	52 ± 3	12	59 ± 6	16	57 ± 4
55–64	3	46 ± 3	12	54 ± 4	15	53 ± 3
65–74	6	45 ± 5	9	52 ± 4	15	49 ± 3
Women						
25–34	2	67 ± 11	31	58 ± 3	33	59 ± 2
35–44	4	48 ± 14	22	52 ± 2	26	51 ± 2
45–54	7	54 ± 16	21	54 ± 3	28	54 ± 2
55–64	9	53 ± 12	17	56 ± 4	26	55 ± 3
65–74	5	61 ± 6	4	55 ± 4	9	58 ± 4
			Triglyceride			
Men						
25–34	...	...	20	181 ± 30	20	181 ± 30
35–44	2	781 ± 638	26	204 ± 36	28	245 ± 55
45–54	6	545 ± 181	15	167 ± 21	21	275 ± 63
55–64	6	217 ± 52	12	152 ± 20	18	174 ± 22
65–74	6	197 ± 42	12	148 ± 15	18	164 ± 18
Women						
25–34	2	279 ± 205	35	142 ± 16	37	149 ± 18
35–44	5	234 ± 32	27	126 ± 9	32	143 ± 12
45–54	10	283 ± 79	24	187 ± 26	34	215 ± 30
55–64	14	167 ± 16	17	146 ± 15	31	155 ± 11
65–74	16	149 ± 12	9	141 ± 19	25	145 ± 12

[1] Mean concentrations shown as mean plus or minus standard error of mean.
[2] Concentrations shown in milligrams per deciliter (mg per dl).
[3] LDL is calculated from the Friedewald equation, LDL = TC minus HDL minus (TG/5). Subjects with TG/of or greater than 400 mg per dl were excluded.

NOTE: LDL = low density lipoprotein cholesterol. TC = serum total cholesterol. HDL = high density lipoprotein cholesterol. TG = triglyceride.

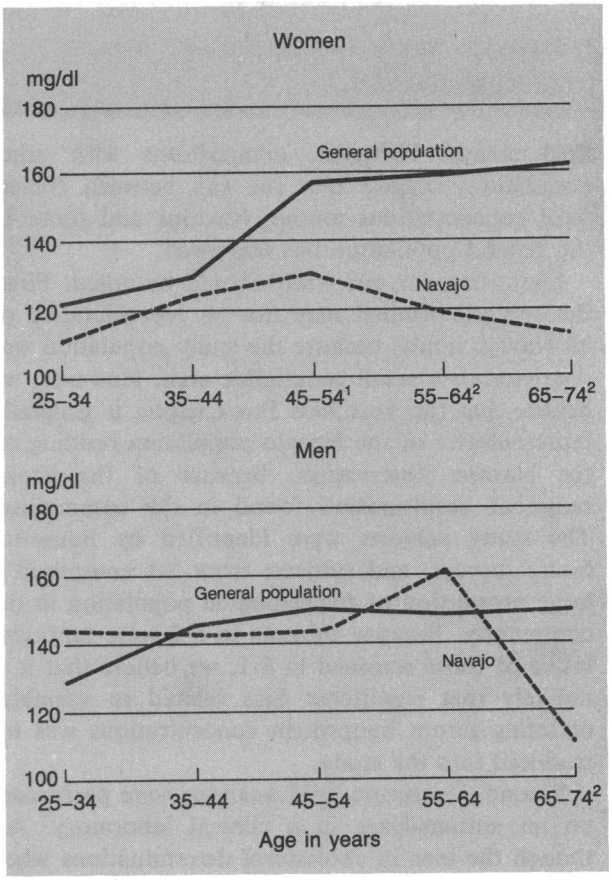
levels among Navajo women ages 55–74 years were significantly lower than those in the general population.

A similar pattern was seen for LDL (figure 2). Although Navajo men had significantly lower mean LDL concentrations only in the 65–74-year age group, Navajo women had significantly lower LDL concentrations than women in the general population for all age groups 45–54 years and older. When comparisons between the general population and Navajos were made, excluding diabetic Navajo subjects, the results were similar to those shown in figures 1 and 2.

The clinical impression that high serum cholesterol concentrations are not rare among Navajos was confirmed. While 27.6 percent of the men ages 25–74 years studied in NHANES II had TC concentrations greater than 240 mg per dl, 33.8 percent of Navajo men had similarly high TC concentrations. However, the prevalence of serum TC concentrations greater than 240 mg per dl among Navajo women (17.5 percent) is about half that among women studied in NHANES II (32.9 percent).

Although mean TC concentrations were higher among diabetics than among nondiabetics in all age groups but one (55–64 years) in both sexes (table 2), the differences were not statistically significant (data not shown). Similarly, although mean TG concentrations were higher among diabetics than among nondiabetics in all age groups among both sexes, the difference reached statistical significance in only one case (women ages 35–44 years). Seven subjects (five diabetic, two nondiabetic) had TG concentrations greater than 500 mg per dl. Two (both diabetic) had TG concentrations greater than 1,000 mg per dl.

Figure 2. Mean serum LDL cholesterol concentrations among 199 Navajo women and men, by age groups 25–74 years, Teec Nos Pos Chapter, Arizona, 1990, and among the general population, 1976–80



[1] $P < 0.01$; [2] $P < 0.001$.

NOTE: U.S. general population, all races, NHANES II. mg/dl = milligrams per deciliter. LDL was calculated from the Friedewald equation, LDL = TC – HDL – (TG/5). Subjects with TG greater than 400 mg/dl were excluded from both data sets.

Discussion

Elevated serum cholesterol concentrations are a risk factor for the development of arteriosclerotic coronary heart disease (*25, 26*). Several investigators have suggested that Navajos had lower mean total cholesterol compared with various reference populations. In 1956, Page and coworkers (*11*) reported that serum cholesterol concentrations among Navajos hospitalized at the Fort Defiance (AZ) Hospital were about 25 percent lower among men and 16 percent lower among women when compared to residents of Cleveland.

Fulmer and Roberts (*4*) reported that mean total cholesterol concentrations among Navajos residing in the Many Farms-Rough Rock area of Arizona in the period 1956 to 1962 were 8 percent lower among men and 14.5 percent lower among women than those from the Framingham study.

In 1961, Kositchek reported lower serum cholesterol concentrations among a small sample of Navajos from Fort Defiance and Shiprock compared to concentrations found in several reference populations (*27*). In 1968, Sievers (*12*) reported that cholesterol concentrations among Navajos were about 20 percent lower than those of whites.

We did not find that serum cholesterol concentrations among Navajo men and younger Navajo women were substantially lower than those among the general population, although concentrations among older Navajo women were lower than those among women in the general population. It is difficult to compare the results of cholesterol concentrations from our study to those from earlier studies, because of methodologic differences in the

'The common link among many of these risk factors among Navajos may be significant changes in diet and activity levels during the previous several decades.'

lipid assays. However, comparisons with other populations suggest that the gap between cholesterol concentrations among Navajos and those in the general population has narrowed.

Limitations of our study should be noted. First, the subjects studied may not be representative of all Navajo adults because the study population was restricted to a small geographic area. However, we believe that the Teec Nos Pos Chapter is generally representative of the Navajo population residing on the Navajo Reservation, because of the broad range of acculturation found in the community. The study subjects were identified by house-to-house surveys, and subjects from S-1 comprised a large proportion of the estimated population in the community. Because subjects in S-2 were representative of those screened in S-1, we believe that it is unlikely that significant bias related to variables affecting serum lipoprotein concentrations was introduced into the study.

Second, the serum lipid analyses were performed on an autoanalyzer in a clinical laboratory. Although the bias in cholesterol determinations when compared to assays performed in a reference laboratory was small (0.9 percent), the biases in HDL (minus 5.0 percent) and TG (6.5 percent) determinations were greater. Thus, comparisons with other populations must be made with caution, especially with regard to small differences in LDL and HDL. However, it is unlikely that the major findings of our study, such as the observation that hypercholesterolemia is no longer rare among Navajos, would be significantly affected by the imprecision of lipid analysis.

Third, because of the small size of the study cohort, our ability to detect significant differences between men and women or diabetic and nondiabetic subjects within age groups may be attenuated. Because the age-adjusted prevalence of NIDDM in the study population was 13.9 percent among men and 18.4 percent among women (*14*), differences in lipoprotein concentrations between diabetic and nondiabetic subjects could affect our findings. However, from a public health perspective, even if a large proportion of those with high cholesterol concentrations were diabetic, the implications for future rates of atherosclerotic coronary heart disease among Navajos are not diminished.

In 1955, Gilbert reported that the clinical diagnosis of myocardial infarction was made for only five Navajos among more than 10,000 admissions and 60,000 outpatient visits to the Fort Defiance Hospital during a 4-year period, and that the diagnoses of the five persons were not confirmed by electrocardiographic criteria (*2*). In a 6-year prospective study of coronary heart disease among Navajos living in the western reservation communities of Rock Point and Many Farms, Fulmer and Roberts found a low incidence of angina, myocardial infarction, and death from coronary heart disease in the population, compared with the general population and the population of the Framingham study (*4*). Sievers and Fisher reported a doubling of the prevalence of myocardial infarctions among Navajos in 1975–78 compared to 1957–66, but the denominators in the study were not population-based (*28*). Although Coulehan and coworkers were unable to identify large increases in the incidence of acute myocardial infarction among Navajos between 1976–79 and 1980–83 (*29*), they found significant increases in 1984–86, compared to prior years (*10*). In 1984–86, they found an annual incidence of 1.1 per 1,000 persons ages 30 years and older, more than twice that in their earlier study.

Navajos have low rates of ischemic heart disease compared with the general population. Although low cholesterol concentrations and low rates of coronary heart disease have been described among the Pima Indians, a small tribe residing in southern Arizona that is culturally distinct from Navajos (*30*), other Indian populations, such as the Sioux, suffer from high rates of ischemic heart disease associated with elevated cholesterols (*31*). Thus, it is important not to generalize data on coronary risk factors collected among specific American Indian and Alaska Native communities to other such communities that are not closely related.

Increasing rates of obesity, NIDDM, and hypertension among Navajos may be a harbinger of rising rates of arteriosclerotic coronary heart disease among them. Contrary to previous reports, we have shown that Navajo adults are not uniformly characterized by low serum lipoprotein concentrations. The common link among many of these risk factors among Navajos may be significant changes in diet and activity levels during the previous several decades.

Although there is a role for the medical treatment of hypercholesterolemia, we believe that primary prevention of the development of these risk

factors should receive a major emphasis among the Navajo people. To this end, community exercise and nutrition education programs are currently being developed and implemented in many Navajo communities.

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Equipment

A. Seca Corporation, 8920A Route 108, Columbia, MD 21045. Compact digital floor scale, model 770.

B. Shorr Productions, 407 Prospect St., Woonsocket, RI 02895. Portable height board.

C. Cambridge Scientific Instruments, Inc., P.O. Box 265, Cambridge, MD 21613. Large skinfold caliper.

D. Becton-Dickinson and Co., Rutherford, NJ 07070. Serum separator tubes.

E. E.I. Dupont de Nemours and Co., Medical Products Dept., Diagnostic Systems, 1600 Hurd Dr., Irving, TX 75038. ACA II autoanalyzer.

F. Technicon Instruments, 511 Benedict Ave., Tarrytown, NY 10591—5097. DAX model 48.

G. Bio-Rad, ECS Division, 3700 E. Miraloma Ave., Anaheim, CA 92806. Lyphochek unassayed chemistry control, serum (bovine) levels 1 and 2.