Total serum cholesterol values obtained from a sample of American Indians on five reservations are significantly lower than those from a Cleveland clinic population.

Serum Cholesterol Levels in American Indians

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AN OPPORTUNITY to examine the level of total serum cholesterol of Indians residing on five reservations in the United States was afforded when the Public Health Service, in cooperation with the U.S. Department of Interior, conducted the Indian Health Survey from October 1955 through June 1956.

Such an examination is of epidemiological interest, since an early study reported infrequent coronary heart disease among the Navajos which prompted an examination by subsequent investigators (*1*, *2*). They found in a small sample of hospitalized Navajos a low serum cholesterol level when compared with that of a clinic group from the Cleveland population, although the Navajo dietary fat intake apparently was not much less than that of the general diet. These findings are contrary to still inconclusive evidence that a high fat intake is reflected in a high concentration of serum cholesterol in the blood and, perhaps, in an increased tendency to develop atherosclerosis (*3*, *4*). It was theorized from these findings that genetic factors, rather than dietary factors, were the principal cause of the low serum cholesterol level and low coronary heart disease occurrence among the Navajos. Other investigators, in studying different groups of the Navajo population, were not impressed that the Navajo mean serum cholesterol level was particularly low. They concluded that the mean level which they observed does not support the hypothesis that the low prevalence of coronary heart disease among the Navajos is a result of low blood lipids (*5*).

It is of particular interest, therefore, to examine the serum cholesterol levels of the American Indians in this survey and to compare these with levels of an American white population having a high mean serum cholesterol level (*2*). The American Indians who were examined resided on the following reservations: Acoma, N. Mex.; Crow, Mont.; Lac Courte Oreilles, Wis.; San Carlos, Ariz.; and Yankton, S. Dak. The relationship with age was also examined and is presented as additional statistical evidence concerning the level of serum cholesterol of populations (*6*).

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Population Studied

The Indian Health Survey was initiated at the request of the 84th Congress, 1st session. The purpose was to determine "the needs and measures necessary to bring Indian health to

an acceptable level." An interview was conducted with members of every household living on each of nine selected Indian reservations; usually only the adults present were interviewed. This aspect of the survey yielded estimates of the extent of illness and the extent of medical care and health facilities available. The results of these interviews are reported elsewhere (*7*).

Clinical examinations were conducted in selected households. The examination consisted of medical history, physical examination, and laboratory tests. The purpose was to obtain more specific information on the extent of illness and disease among Indians than was obtained by the household interview. A random sample of members of households on five of the original nine survey reservations was taken for this purpose. Household serial numbers assigned at the time of the initial house-to-house survey were used to select examinees.

Methods

Total serum cholesterol was determined by the method of Abell and associates (*8*). Blood samples of adult Indians were collected and shipped to the National Heart Institute Laboratory at Framingham, Mass., for determination of serum cholesterol values. The Cleveland Clinic Foundation employed a similar method in obtaining total serum cholesterol values of the white population group used for comparison. Both the laboratories, Framingham and Cleveland, had previously established the reproducibility of their total serum cholesterol measurements (*9*).

State of Health

Levels were determined for clinically healthy Indians as well as for those who were found to have diseases or conditions that influence the serum cholesterol level. To conform with the practice of other reporting investigators, however, only those Indians are included here whose state of health was uncomplicated by conditions which might affect serum cholesterol. Women whose clinical records showed that they were pregnant were excluded.

Results

Table 1 summarizes the values of total serum cholesterol of clinically healthy Indian men and women residing on five Indian reservations. For men, the mean serum cholesterol levels range from a low of 193 mg. per 100 cc. for San Carlos Indians to a high of 224 mg. per 100 cc. for Crow Indians. For all reservations, Indian women show consistently lower mean serum cholesterol levels than Indian men. Women residing on the San Carlos Indian Reservation show the lowest mean serum cholesterol value,

Table 1. Serum cholesterol levels in American Indians on five reservations, by sex

Sex and reservation	Number of persons	Serum cholesterol (mg. per 100 cc.)			Age	
		Mean	Standard deviation	Range	Mean	Standard deviation
Male						
Crow	28	223.8	41.4	106–310	35.5	9.3
Yankton	21	209.9	38.0	154–296	35.9	10.6
Acoma	25	223.0	60.3	98–336	38.7	11.0
San Carlos	21	193.5	28.5	143–255	36.4	13.0
Lac Courte Oreilles	16	212.6	49.1	125–301	38.4	9.0
Female						
Crow	26	200.2	45.3	137–345	34.8	9.3
Yankton	15	209.1	56.5	137–335	31.0	9.5
Acoma	40	191.7	36.0	154–262	34.8	12.3
San Carlos	34	189.4	41.4	114–287	32.1	8.6
Lac Courte Oreilles	32	199.9	45.1	92–273	38.1	9.6

189 mg. per 100 cc. Women residing on the Yankton Reservation show the highest mean serum cholesterol value, 209 mg. per 100 cc.

Data were combined for each sex without regard to reservation because of the small numbers of serum cholesterol determinations done at each location. Pooling of data seemed justified because there were no significant differences in mean cholesterol among Indians on different reservations. [Males: $F>1.71$ ($F_{.05}<2.46$). Females: $F>0.77$ ($F_{.05}<2.44$).] Although this sample is homogeneous in regard to serum cholesterol, it is recognized that certain genetic and cultural differences exist between the different tribes. Mean cholesterol levels of Indians were compared with those obtained from the Cleveland Clinic Foundation which had been used for comparison with the level of serum cholesterol of a group of Navajos. The mean levels of the Cleveland group have been found to be in the same range as the levels for other population groups (*9*). Since the original clinic data were divided into two age groups (*2*), the American Indian serum cholesterol data were similarly divided, with the age means and standard deviations comparable for both groups.

Indian men and women show a significantly lower mean serum cholesterol than Cleveland men and women for the two age groups (table 2).

Table 3. Serum cholesterol level of selected American Indian males, by age

Age group, in years	Number of males	Serum cholesterol (mg. per 100 cc.)	
		Mean	Standard deviation
20–29	31	193. 5	29. 3
30–39	33	227. 4	47. 2
40–49	28	217. 8	51. 7
50–59	19	216. 4	45. 8

Further evidence of the level of serum cholesterol of a population involves knowledge of the relationship between age and cholesterol. Ample evidence exists that serum cholesterol levels are, in part, dependent on age. Populations with high serum cholesterol generally show a significant rise in serum cholesterol after the thirties, while populations with low serum cholesterol do not show such a rise during this period (*6*). On the other hand, there are significant increases in serum cholesterol with age in the younger age group to about the thirties in both low and high serum cholesterol populations.

In the low serum cholesterol populations, the mean serum cholesterol reached a plateau after the thirties in the Naples, Italy, area (*6*).

Table 2. Serum cholesterol levels by age of selected American Indians and a Cleveland white group

Sex and age group	American Indians					Cleveland white group [1]					Comparison (*P*)
	Number of persons	Serum cholesterol (mg. per 100 cc.)		Age		Number of persons	Serum cholesterol (mg. per 100 cc.)		Age		
		Mean	S.D.	Mean	S.D.		Mean	S.D.	Mean	S.D.	
Male											
Young	64	211	42.8	29	6.1	58	230	33.5	27	8.4	[2] $<.05$
Older	47	217	49.5	47	5.5	99	242	29.9	45	9.0	[2] $<.05$
Female											
Young	105	192	42.9	29	6.0	42	216	58.4	26	7.8	[2] $<.05$
Older	42	206	42.5	47	4.7	55	230	44.5	43	7.5	$<.05$

[1] Reference 2.

[2] Cochran and Cox approximate method used to test the hypothesis of equality of means with no hypothesis about the population variance: when $n_1 \neq n_2$ and $s_1 \neq s_2$. Snedecor, G. W., Statistical Methods, Ed. 4, Ames, Iowa, Iowa State College Press, 1946, p. 83.

S.D.—Standard deviation.

Table 4. Statistical tests of the presence of significant age-cholesterol relationship and of departure from linearity of selected American Indian males

Age group, in years	*F* test	
	Linear trend	Departure from linearity
20–39	[1] 10.49	0.73
40–59	.05	1.50

[1] Significant at 1 percent level.

From the early thirties to the fifties, the level of serum cholesterol in low-income working men of Madrid, Spain (*10*), tended to decline instead of rising so that the cholesterol levels at these ages were much lower than those of high serum cholesterol level populations.

In high serum cholesterol populations, such as middle-income men in Minnesota (*11*), professional men in Madrid (*10*), and Jewish and Italian workers in New York (*12*), serum cholesterol levels show a rise into the fifties. It should be noted, however, that the study of the age-cholesterol relationship in a high serum cholesterol population in New York did not determine significant age-cholesterol relationship beyond the thirties (*13*).

Table 3 shows the mean serum cholesterol level of Indian men by age. The mean serum cholesterol rises from ages 20 through 39 years, levels off, and remains fairly constant in the older ages. In order to test the significance of the age-cholesterol relationship, analysis of variance and regression analysis were made. This age-cholesterol relationship analysis was made for age groups in which *F* tests indicated no significance of deviation from linearity. For Indian men, *F* tests of linearity of age-cholesterol relationship indicated two age groups, 20–39 years and 40–59 years. *F* tests also show that for Indian men there is a significant age-cholesterol relationship in the younger age group, 20–39 years. Significant age-cholesterol relationship is not evident in the older age group, 40–59 years. Statistical tests of the presence of significant age-cholesterol relationship and of the departure from linearity are presented in table 4.

Regression equations for two age groups showing the relationship between age and cholesterol are presented in table 5. For the younger age group there is a significant increase in total cholesterol level, averaging about 3 mg. per 100 cc. per year. In the older age group the average increase is less than one-half mg. per 100 cc. per year, which is not a significant increase.

Table 5 also shows that the predicted mean serum cholesterol value determined from the regression equation for males of ages 20–39 years with an average age of 29.2 years is 211 mg. per 100 cc. The corresponding predicted mean serum cholesterol value for males of age 40–59 years, with an average of 47.3 years, is 217 mg. per 100 cc.

Significant age-cholesterol relationship displayed in the younger age group of the American Indian series is similar to the serum cholesterol level pattern of change with age found in the younger age group of both low and high serum cholesterol populations. The fact that

Table 5. Age and serum cholesterol level relationship of selected American Indian males

Age group, in years	Number	Age		Serum cholesterol (mg. per 100 cc.)				Standard error of slope
		Mean	Standard deviation	Mean	Standard deviation	*a* [1]	*b* [1]	
20–39	64	29.2	6.1	210.9	39.9	133.2	+2.66	[2] 0.82
40–59	47	47.3	5.5	217.1	50.0	203.4	+.29	[3] 1.33

[1] The values for *a* and *b* are constants with regression equation: cholesterol=$a+b$ (age). The average annual change of serum cholesterol concentration in mg. per 100 cc. is indicated by the regression coefficient *b* in the regression equation. *X* is equal to age in years; *y* is equal to serum cholesterol level.

[2] Slope significantly different from zero slope.

[3] Slope is not significantly different from zero slope.

serum cholesterol does not continue to rise after age 39 years in the Indian group places this group in the same category as other low serum cholesterol populations which have been mentioned.

Discussion

This study attempted to determine whether level of serum cholesterol of clinically healthy Indians residing on five reservations in the United States is low or high in comparison with the levels usually accepted for general U.S. populations.

It was found that the level of serum cholesterol of this American Indian series was significantly lower than that of a sample group from the Cleveland clinic. This supports the findings of an earlier study, in which it was found that the level of serum cholesterol of a sample of hospitalized Navajos was significantly lower than that of the Cleveland clinic group (*2*).

Data from this American Indian series are not available regarding the first and third variables of the interrelationship of fat content of diet to serum cholesterol level to atherosclerosis (and coronary heart disease). When three variables were examined in an earlier study, it was observed that because estimated Navajo dietary fat was not much less than that of the general American level, genetic rather than dietary factors might be largely responsible for low serum cholesterol and low coronary heart disease frequency (*2*).

Certain suggestive data are available regarding one genetic characteristic of this American Indian series. These data pertain to the quantum of Indian blood for each reservation and were obtained from interviews conducted during the health survey. There is some reason for overstatement of Indian ancestry because

Relation between quantum of Indian blood and mean serum cholesterol.

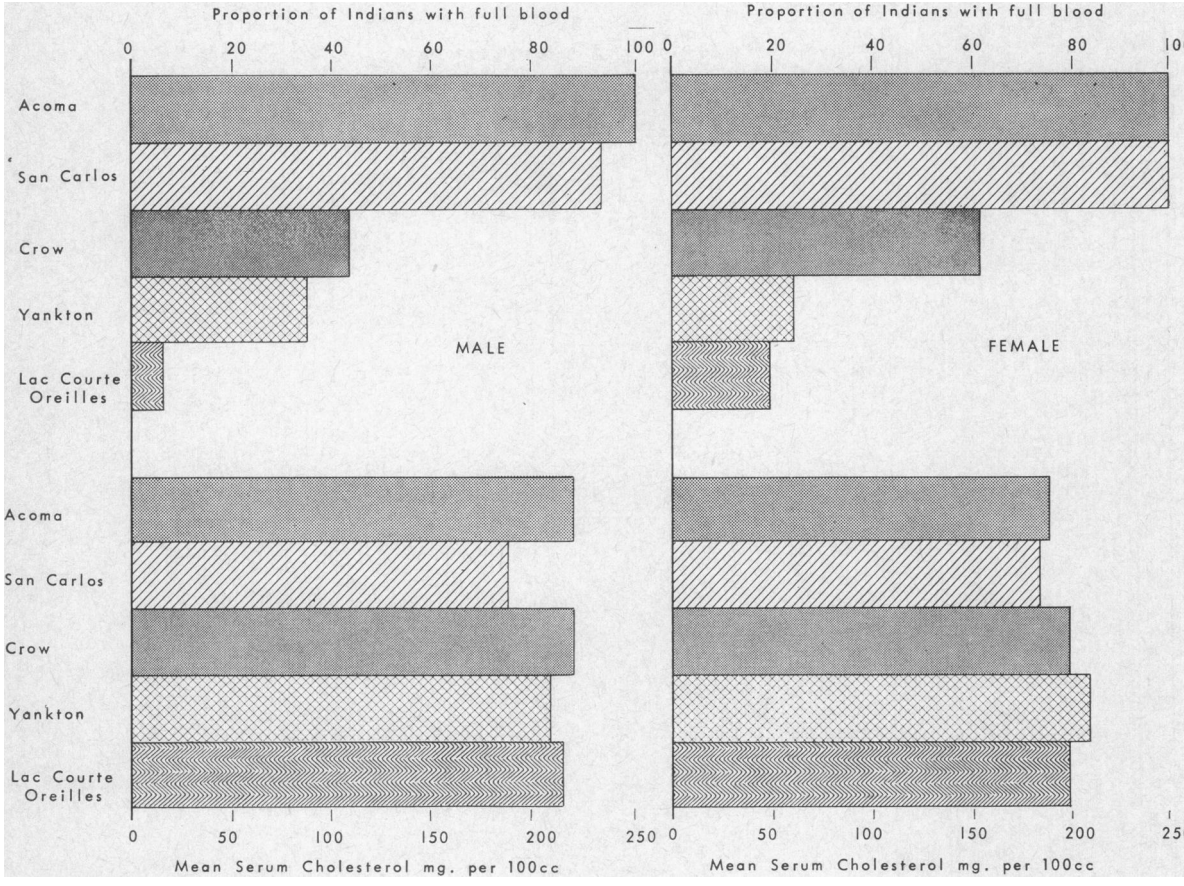

Table 6. Comparison of mean serum cholesterol levels between two blood groups of American Indians on five reservations

Sex	Full blood					Less than full blood					Comparison (P)
	Number of persons	Serum cholesterol (mg. per 100 cc.)		Age		Number of persons	Serum cholesterol (mg. per 100 cc.)		Age		
		Mean	S.D.	Mean	S.D.		Mean	S.D.	Mean	S.D.	
Male	64	216. 5	45. 8	37. 4	10. 4	45	209. 8	37. 7	35. 8	9. 7	$>.05$
Female	100	191. 5	36. 3	33. 7	9. 2	45	202. 5	48. 7	36. 9	8. 6	[1] $>.05$

[1] See footnote 2, table 2.

S.D.—standard deviation.

receipt of many benefits depends on having a minimum of one-fourth Indian blood (*7*). Enumerators in the survey were recruited from reservations, which may have tended to minimize overstatement of quantum of Indian blood.

If the genetic factor as measured by this subjective self-reporting of ancestry is operating to lower serum cholesterol in the Indian population, the reservations with larger proportions of full-blooded Indians should tend to have lower serum cholesterol levels. The chart shows that while there is great variation in proportion of Indians with full blood among the five reservations, there is no relationship between proportion of Indians with full blood and the mean serum cholesterol levels.

Another approach to analyzing the relationship of the quantum of Indian blood and serum cholesterol level was made by dividing the men and women into two groups, those with full blood and those with less than full blood. As indicated in table 6, these two groups, both men and women, have comparable mean ages and standard deviations. This approach confirms the previous analysis by indicating that there is no significant difference in mean serum cholesterol level between the two groups for each sex. It is apparent, however, that more objective measures of genetic characteristics would be necessary before any definite conclusions could be drawn regarding the relationship of genetic factors and serum cholesterol level.

As indicated previously, Darby and associates (*5*) studied two groups of Navajo Indians. One was centered about Ganado, a missionary center. This group consumed fat-rich foods much more frequently and had a mean serum cholesterol level which was significantly higher than the other group of Navajos studied at Pinon, an area located in the interior of the Navajo reservation. It would appear, therefore, that within an ethnically similar group there are considerable internal differences in diet and serum cholesterol patterns.

It must be recognized that various subgroups of Navajos may be ethnically dissimilar. Whether such blood lipid variations are, in turn, associated with differences in morbidity and mortality from coronary heart disease (as might be expected in view of the implication of hyperlipemia in the current popular working hypothesis of causation of coronary heart disease) suggests a fruitful area for epidemiological study of the Navajos, by far the largest American tribe of Indians and possibly the most primitive. Additional impetus to further study of the Navajos stems from another study which indicates that their death rate for cardiovascular diseases is significantly lower than that of all other American Indian tribes (*14*).

Summary

1. Total serum cholesterol determinations were obtained from five tribes of American Indians who were examined during the Indian Health Survey.

2. No statistically significant difference in their mean serum cholesterol levels was found among the different tribes, but the samples were

too small to conclude that clinically significant differences do not exist.

3. The serum cholesterol level of this American Indian series was significantly lower than that of the Cleveland clinic group, whose mean level is similar to that found in other surveys of American non-Indian populations.

4. The finding is in agreement with the results of a study which found that Navajo Indians have a significantly lower serum cholesterol level than that of a similar American clinic population.

5. The finding, in another study, of a higher serum cholesterol level among one subgroup of the Navajos and of a significantly lower mean level among another subgroup suggests important environmental factors at work among this ethnic group. The circumstance lends itself favorably to further epidemiological study of dietary patterns, blood lipid levels, and occurrence of coronary heart disease among the Navajos.

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Shellfish Sanitation Laboratory Moves

The Shellfish Sanitation Laboratory, Robert A. Taft Sanitary Engineering Center, has moved from Gulf Breeze, Fla., to Purdy, Wash. The new mailing address is: U.S. Department of Health, Education, and Welfare, Public Health Service, Shellfish Sanitation Laboratory, Star Route Box 576, Gig Harbor, Wash.