Serum Total Cholesterol: HDL Cholesterol Ratios in US White and Black Adults by Selected Demographic and Socioeconomic Variables (HANES II)

Shai Linn, MD, DrPH, Robinson Fulwood, MSPH, Margaret Carroll, MSPH, J. Gerald Brook, MD, Clifford Johnson, MSPH, William D. Kalsbeek, PhD, and Basil M. Rifkind, MD

ABSTRACT

Background: Framingham Study findings suggest that total cholesterol (TC):High density lipoprotein cholesterol (HDL-C) ratio is a useful summary of the joint contribution of TC and HDL-C to coronary heart disease (CHD) risk. Information on the distribution of TC:HDL-C in the US population is limited to selected populations and the relationship of the ratio distribution and its correlates has received little attention.

Method: TC/HDL-C ratios were examined in a representative sample of the United States adult population ages 20 to 74 years, between February 1976 and February 1980 during NHANES II, using stratification and multivariate regression analyses.

Results: Age-adjusted mean ratios were higher in men compared with women and were higher in Whites compared with Blacks. White men had the highest TC/HDL-C mean ratios. These relationships remained after stratification by age, education, body mass index, alcohol use, cigarette smoking, and physical activity. Using multivariate analyses, the ratios were positively related to BMI, age, and smoking; and negatively related to female sex, alcohol use, being Black, and physical activity.

Conclusions: Using a ratio reference point of greater than or equal to 4.5 from the Framingham study, at least an estimated 44 million persons ages 25 to 74 years in the US were found to be at higher risk of developing coronary heart disease. (*Am J Public Health*. 1991;81:1038–1043)

Introduction

The various cholesterol-carrying lipoproteins are independent predictors of coronary heart disease (CHD) risk. Plasma total cholesterol (TC) and low density lipoprotein cholesterol (LDL-C) levels are positively correlated with CHD, whereas high density lipoprotein cholesterol (HDL-C) levels are inversely related.[1] However, TC or LDL-C and HDL-C are poorly correlated with each other so that knowledge of both may be important to predict CHD risk than does either of them alone.

Various ratios combining TC or LDL-C and HDL-C have been introduced. Framingham Study findings suggest that TC:HDL-C ratio is a useful summary of the joint contribution of TC and HDL-C to CHD risk.[1–3]

Other summary measures, using LDL-C, may need calculations or special laboratory methods. We have chosen to report the TC:HDL-C to allow comparison with the Framingham data, since it is the main source of information on the relationship of a summary measure of TC and HDL-C with CHD mortality. This ratio has the advantage of being available to the physician and is easier to comprehend at the clinical level.

Information on the distribution of TC:HDL-C (or its inverse) in the United States population is limited to selected populations. Both the Framingham Study[1,3] and the Lipid Research Clinics (LRC) Prevalence Study[4] were not planned to be representative of the US population. Furthermore, the relationship of the ratio distribution and its correlates has received little attention.

The second National Health and Nutrition Examination Survey (NHANES II),[5,6] measured TC and HDL-C levels in a probability sample of the civilian, noninstitutionalized population of the United States and thus provides information on the distribution of the TC:HDL-C ratio for categories of selected potential correlates, namely age, sex, race, education, body mass index (BMI), alcohol intake, smoking, and physical activity.

Methods

The NHANES II, conducted between February 1976 and February 1980 by the National Center for Health Statistics (NCHS), was a national cross-sectional probability survey of the civilian noninstitutionalized population of the United States aged 6 months to 74 years including Alaska and Hawaii.[5,6] It consisted of household interviews, as well as physical examination and interviews in mobile examination centers. The household interview collected socioeconomic

From the Lipid Metabolism-Atherogenesis Branch, National Heart, Lung and Blood Institute, NIH, Bethesda (Linn, Brook, Rifkind); the Nutrition Statistics Branch, National Center for Health Statistics, Hyattsville, MD (Fulwood, Carroll, Johnson); the Collaborative Studies Coordinating Center, Department of Biostatistics, University of North Carolina, Chapel Hill (Kalsbeek); and the Clinical Epidemiology Unit, Rambam Medical Center, Haifa, Israel (Linn).

Address reprint requests to Basil M. Rifkind, MD, Chief, Lipid Metabolism-Atherogenesis Branch, Division of Heart and Vascular Diseases, NHLBI, NIH, Federal Building, Room 401, Bethesda, MD 20892. This paper, submitted to the Journal April 30, 1990, was revised and accepted for publication January 23, 1991.

and demographic information on the sample person and the family and a medical history questionnaire. The medical examination was conducted according to a standardized protocol and included laboratory tests on whole blood and sera. For each person examined, dietary data including alcohol consumption were obtained by means of a 24-hour recall and a three-month food frequency questionnaire administered by trained dietary interviewers.

The three sources of nonresponse and response rates by sex and race are shown in Table 1. An analysis of selected health variables of persons who were examined versus those who were not examined (but interviewed) indicated no substantial bias due to nonresponse.[7] An examination of the characteristics of persons with and without HDL-C determinations such as age, education, BMI, alcohol use, smoking, and physical activity did not detect differences that would suggest a bias in the results. Adjustments have been made according to the usual NCHS methods so that the results reported here reflect a nationally representative sample.[5]

TABLE 1—NHANES Study population: Numbers and response rates by sex and race

		Men		Women	
	Total*	White	Black	White	Black
Total sample	17058	7059	852	8044	1103
Interviewed	15080	6170	766	7146	998
Response rate (%)	88.4	87.4	89.9	88.8	90.5
Examined	11637	4483	607	5418	729
Response rate (%)	77.2	79.1	79.2	75.8	73.0
HDL determinations	9625	4019	462	4563	581
Response rate (%)	82.7	82.3	76.1	84.2	79.7
Overall response Rate (%)	56.4	56.9	54.2	56.7	52.7

*Includes only Whites and Blacks aged 20–74 years.

Determination of Serum Lipids

Chemical analyses were provided by the LRC Laboratory at the George Washington University, and the editing and data processing were provided by the LRC Central Processing Unit, Department of Biostatistics, at the University of North Carolina. The laboratory techniques have been described elsewhere.[5,8]

Definitions

Educational level: Measured by the highest grade attended in a public or a private school.

Body mass index (BMI, Quetelet index): Weight (Kg)/height (m)}**2.

Frequency of alcohol consumption: Participants were asked about the usual consumption of alcoholic beverages during the three months that preceded the interview. Consumption was classified as follows: none (never), less than once/week (seldom), 1 to 6 times/week (weekly), or 1 or more times/day (daily). The data for all types of alcohol—beer, wine, and liquor—were compared. The greatest frequency of reported alcohol use was calculated as a composite measure of habitual (chronic) frequency of alcohol use of any kind.

Smoking: Interviewers were asked: 1) whether they had ever smoked at least 100 cigarettes during their entire life; 2) whether they currently smoked; and 3) the daily number of cigarettes smoked. Individuals who responded positively to questions #1 and #2 were defined as "current smokers." Those who responded positively to question #1 but negatively to question #2 were defined as "past smokers," and those who responded negatively to question #1 were defined as "nonsmokers." For current smokers, the data were dichotomized into those who smoked fewer than 21 cigarettes per day, and those who smoked 21 or more cigarettes per day.

Physical activity: Interviewees were asked: 1) whether they were getting "much exercise," "moderate exercise," or "little or no exercise" for recreation; 2) whether in their usual day, aside from recreation, they were "very active," "moderately active," or "quite inactive." The higher category of activity, at any time was then calculated as a composite of activity of any kind.

Statistical Methods

All statistical analyses incorporated both the weights and the complex sample design of the NHANES II. Age-specific and age-adjusted mean HDL-C levels of men and women by race and by selected correlates were estimated by use of the programs SURREGR[9] and GENCAT.[10,11] The age-adjusted means were standardized by the direct method to the 1980 US census population. The first level of analysis consisted of testing the equality in age-specific mean and the age-adjusted mean ratio by selected correlates for the four sex-race groups. Hypotheses of no difference in mean ratio were tested at the 0.05 level of significance, using a chi-square statistic with one degree of freedom. For this report the use of the word "significant" implies "statistically significant."

Second, Pearson correlation coefficients were estimated to investigate the relationship between the ratio and continuous variables such as age, years of education, and the number of cigarettes currently smoked. Correlation coefficients and standard errors were estimated by use of the program OSIRIS.[12] Since the sampling distribution of the correlation coefficients is not normal, Fisher's Z transformation of the correlation coefficients was used to test the hypothesis of zero correlation.

Third, using the SURREGR program, weighted least squares multiple regression analyses,[9] with ratio as the dependent variable, were applied to control for potential confounding. All correlates were included simultaneously in the equation.

Results

The mean ratios and selected percentiles by age, sex, and race are presented in Table 2. The ratios were directly related to age ($P < 0.001$) with Pearson correlation coefficients of 0.235 for White men, 0.207 for Black men, 0.301 for White women, and 0.247 for Black women. White men had the highest mean ratios, consistently increasing from 4.11 at ages 20 to 24 to a peak of 5.55 at ages 45 to 54, and declining thereafter.

The ratios for White men were consistently and significantly higher than those of White women. The age-adjusted sex difference for Whites was 0.77 (18 percent higher for males). Black men had higher ratios than Black women at ages 25 to 54, but Black women had higher ratios in the youngest age group 20 to 24 and at age 55 and above. Blacks had consistently lower ratios than Whites, for both men and women. All differences for men were significant.

TABLE 2—Ratio of Total Cholesterol to HDL Cholesterol (mg/dl) of Adults Ages 20–74 Years by Sex, Race, and Age, with Means, Age-Adjusted Means, and Selected Percentiles, United States 1976–80

	Examined Persons	Estimated Population in Thousands	Selected Percentiles									
			Mean	5th	10th	15th	25th	50th	75th	85th	90th	95th
MEN												
Whites												
20–74	4,019	55 808	5.06	2.79	3.17	3.43	3.88	4.81	5.98	6.72	7.29	8.13
Age-adjusted mean ratio			5.05									
20–24	494	8 052	4.11	2.39	2.72	2.95	3.25	3.98	4.75	5.31	5.67	6.51
25–34	751	13 864	4.75	2.58	3.05	3.32	3.74	4.51	5.53	6.22	6.72	7.57
35–44	545	9 808	5.31	3.14	3.41	3.62	4.06	4.97	6.26	6.97	7.79	8.21
45–54	506	9 865	5.55	3.14	3.50	3.86	4.35	5.39	6.49	7.24	7.78	8.79
55–64	865	8 642	5.47	3.08	3.47	3.80	4.17	5.19	6.51	7.25	7.82	8.54
65–74	858	5 576	5.30	2.86	3.32	3.55	4.03	5.11	6.24	6.84	7.39	8.25
Blacks												
20–74	462	6 102	4.28	2.24	2.59	2.77	3.08	4.00	5.11	5.69	6.22	7.36
Age-adjusted mean ratio			4.33									
20–24	65	1 043	3.43	+	2.24	2.44	2.64	3.22	4.20	4.41	4.70	+
25–34	112	1 546	4.16	2.37	2.59	2.74	3.06	3.91	5.04	5.64	6.06	7.00
35–44	54	1 112	4.69	+	2.91	3.34	3.53	4.45	5.26	6.07	6.75	+
45–54	47	1 044	4.75	+	+	2.83	3.54	4.17	5.44	6.09	+	+
55–64	92	801	4.50	+	2.79	3.00	3.38	4.28	5.47	6.30	6.69	+
65–74	92	555	4.49	+	2.67	2.84	3.32	4.13	5.18	5.69	6.64	+
WOMEN												
Whites												
20–74	4,563	60 785	4.30	2.42	2.68	2.88	3.18	3.98	5.04	5.79	6.30	7.24
Age-adjusted mean ratio			4.28									
20–24	542	8 408	3.66	2.23	2.43	2.59	2.90	3.42	4.20	4.64	5.14	5.72
25–34	875	14 494	3.90	2.40	2.58	2.74	2.98	3.63	4.51	5.07	5.58	6.61
35–44	626	10 584	4.20	2.45	2.66	2.86	3.19	3.98	4.97	5.56	6.06	6.74
45–54	546	10 369	4.57	2.45	2.80	3.00	3.33	4.35	5.47	6.05	6.60	7.60
55–64	973	9 601	4.81	2.63	2.91	3.12	3.57	4.52	5.67	6.56	7.18	8.17
65–74	1,001	7 329	5.00	2.88	3.16	3.36	3.83	4.75	5.89	6.73	7.16	8.03
Blacks												
20–74	581	7 579	4.06	2.30	2.51	2.69	2.98	3.70	4.70	5.60	6.26	7.05
Age-adjusted mean ratio			4.10									
20–24	77	1 304	3.45	+	2.39	2.57	2.67	3.22	4.13	4.68	4.95	+
25–34	122	1 953	3.76	2.22	2.38	2.52	2.84	3.41	4.47	5.45	5.86	6.47
35–44	84	1 415	4.12	+	2.45	2.69	2.96	3.87	4.68	5.39	6.52	+
45–54	81	1 215	4.35	+	3.00	3.07	3.19	3.96	5.16	6.42	6.64	+
55–64	99	959	4.78	+	2.60	2.96	3.11	4.21	5.95	7.19	7.64	+
65–74	118	733	4.50	2.52	2.97	3.23	3.59	4.32	5.15	5.78	5.81	7.07

[1]Age-adjusted by direct method to the 1980 U.S. Census Population.
+Sample size is inadequate to produce a reliable estimate.

TC:HDL-C by Categories of Correlates

Education: In Whites, there was a slight initial increase in the ratios from the first to the second category of education, and a consistent decline thereafter. However, for Black men there was a decrease in the ratio from the first to the second level of education, and a consistent increase with higher education. There was no clear trend in the ratio for Black women. The correlation coefficients were negative in all four sex-race groups, suggesting an inverse relationship between education and the ratio (data available on request from authors).

BMI: The ratios increased uniformly in all four sex-race groups with increasing BMI (Table 3). The relationships of the ratio with BMI were stronger in women than in men, and in Blacks than in Whites.

Alcohol: The age-adjusted mean of Whites of both sexes and of Black women decreased consistently with increased frequency of alcohol consumption (Table 4). The ratio of Black men was highest for those who seldom consumed alcohol and decreased consistently thereafter. For each of the four sex-race groups except for Black men there were lower ratios with increasing reported quantities of alcohol consumed over the last 24 hours. The Pearson correlation coefficients were stronger in men than in women and in Whites than in Blacks.

Smoking: In all groups with the exception of Black men, nonsmokers had lower ratios than smokers (Table 5). However, Black men who never smoked and past smokers had higher ratios than light smokers. Among the smokers, the heavier the smoking the higher the ratio in all groups with the exception of Black females, where the number of cases was too small to produce a reliable estimate.

Physical activity: White men and women, and Black men and women had the lowest ratios with highest level of reported physical activity (Table 6).

TC:HDL-C Ratio in the Four Sex-Ratio Groups after Stratification for Correlates

Sex and race patterns remained basically similar to the findings in the basic data even after controlling for correlates: Of the four sex-race groups, White men consistently had the highest ratios; and Black women had the lowest ratios after stratification for BMI and alcohol consumption (data available on request from authors).

Multivariate Analyses

In the multivariate model with all correlates (Table 7), BMI, age, and current smoking were positively and independently related to the ratio. Being female, frequent alcohol use, being Black, and physical activity were negatively and independently related to the ratio. In this model, education was not strongly related to the ratio. Similar results were obtained when the natural log of the ratio was used as a dependent variable.

TABLE 3—Age-Adjusted Mean Ratio of Total Cholesterol to HDL Cholesterol of Adults, Ages 20–74 Years, by Race, Sex, and Quartiles of Body Mass Index (BMI), and Pearson Correlation Coefficient, United States, 1976–80

Men Quartiles of BMI	*White*	*Black*
Less than 22.7	4.45	3.59
22.7–24.9	4.86	4.07
25.0–27.5	5.25	4.65
27.6 or more	5.67	5.10
Pearson Correlation	0.302*	0.358*
Women Quartiles of BMI	*White*	*Black*
Less than 21.2	3.82	3.25
21.2–23.7	4.06	3.52
23.8–27.4	4.37	3.98
27.5 or more	4.99	4.60
Pearson Correlation	0.313*	0.367*

Age-adjusted by direct method to the 1980 US Census population.
Body mass index quartiles were determined from sex-specific BMI distribution.
*$P < 0.001$

TABLE 4—Age-Adjusted Mean Ratio of Total Cholesterol to HDL Cholesterol of Adults, Ages 20–74 Years, by Race, Sex, and Frequency of Consumption of Alcoholic Beverages, United States, 1976–80

Frequency of Consumption	White Men	Black Men	White Women	Black Women
Never	5.42	4.44	4.51	4.30
Seldom	5.20	4.65	4.32	4.19
Weekly	4.92	4.19	4.05	3.76
Daily	4.74	3.77	3.63	3.53

Age-adjusted by direct method to the 1980 US Census population.
Frequency of consumption of alcoholic beverage was determined by taking the maximum reported consumption of either beer, wine, or liquor from the food frequency questionnaire.

TABLE 5—Age-Adjusted Mean Ratio of Total Cholesterol to HDL Cholesterol of Adults, Ages 20–74 Years, by Race, Sex, and Smoking Status, and Pearson Correlation Coefficient, United States, 1976–80

Smoking Status	White Men	Black Men	White Women	Black Women
Nonsmokers	4.97	4.46	4.19	4.03
Past smokers	4.99	4.51	4.12	4.21
Smokers				
1–20 cigarettes/day	5.05	4.01	4.45	4.17
21 cigarettes or more/day	5.38	4.54	4.53	—
Pearson Correlation	0.141*	—	0.049	—

Age-adjusted by direct method to the 1980 US Census population.
A past-smoker is defined as a person who had smoked at least 100 cigarettes but does not currently smoke; a nonsmoker did not smoke 100 cigarettes in his lifetime and does not currently smoke.
*$P < 0.001$.
—Sample size is inadequate to produce a reliable estimate.

Discussion

The present report provides estimates of the distribution of the TC:HDL-C ratio and the relationship to selected correlates in a representative sample of the United States population. The ratios were found to increase with age in men and women of both races. The ratios were consistently higher for men compared to women for the two races; and Whites had higher ratios compared to Blacks. These relationships remained even after stratification for categories of correlates.

The age and sex trends of the TC:HDL-C ratios were similar to those seen in the Framingham study which, however, found higher values. The socioeconomic status (SES) of the Framingham population is higher than that of the general US population. However, since higher SES was found to be related to lower ratios in the present study, SES does not account for the differences observed in the two studies. Laboratory and other methodological differences in lipids and lipoprotein determinations could account for some of the differences. A bias in the determination of lipid levels in NHANES II seems to be unlikely. All TC and HDL-C determinations were performed using a standardized procedure, without knowing the participants demographic characteristics and the quality of the laboratory determinations were routinely evaluated.

In the univariate analyses the ratio was negatively related to years of education in the four sex-race groups but when other correlates were considered in a multivariate model, the ratio was only weakly positive and weakly related to education.

Some limitations on the use and interpretation of the ratio may be advised. It is important to emphasize that the TC:HDL-C can change as a function of either TC or HDL-C. Furthermore, the relationship to correlates is complicated by the fact that at any given ratio level a number of correlates can influence infinite combinations of TC and HDL-C and be responsible for the final outcome. Some correlates such as age will have their effect via TC since there is no strong relationship between age and HDL-C. Conversely, alcohol consumption, for

TABLE 6—Age-Adjusted Mean Ratio of Total Cholesterol to HDL Cholesterol of Adults, Ages 20–74 Years, by Race, Sex, and Physical Activity, United States, 1976–80

Physical Activity Level	White Men	Black Men	White Women	Black Women
Quite inactive	5.31	4.31	4.46	4.80
Moderately active	5.12	4.49	4.28	4.06
Very active	4.96	4.12	4.23	3.89

Age-adjusted by direct method to the 1980 US Census population.

TABLE 7—Multiple Linear Regression Model with Ratio of Total Cholesterol to HDL-Cholesterol as a Dependent including all Correlates

Overall R^2: 0.212 Intercept 1.969	B[a]	partial R^2 (%)
BMI	0.089[b]	9.16
Age (years)	0.022[b]	4.16
Sex (women vs men)	−0.773[b]	4.34
Current smoker	0.409[b]	1.23
Alcohol use (never or seldom vs others)	−0.430[b]	1.13
Race (Blacks vs Whites)	−0.575[b]	1.10
Physical activity (very active or moderate vs inactive)	−0.089[c]	0.07
Education (years)	0.002	0.00

[a]Estimated regression coefficient.
[b]$P < 0.001$.
[c]$P < 0.05$.

example, will predominantly affect HDL-C. BMI on the other hand is known to influence both components of the ratio, and indeed proved to be the most important predictor of TC:HDL-C in the multivariate analyses. Several publications have investigated the relationships of TC or HDL-C to demographic and socioeconomic variables in the US.[5,13–15] When assessing the distribution of the ratio and its correlates, these factors must be taken into consideration.

In the Framingham Study, the TC:HDL-C ratio was found to be an excellent predictor of CHD risk. Men and women who did not develop CHD within the years of follow-up had an average ratio of 5.2. For those who did develop CHD over the same period, the average ratio for men was 5.8 and for women 5.3. The American Heart Association guidelines suggest that to consider all those at or above ratios of 4.5 be considered at higher risk of CHD[1,16] as TC:HDL-C ratio of 4.4 corresponds to total cholesterol level of 200 mg/dl and HDL-C of 45 mg/dl. Using this single reference ratio, Castelli[1] estimated that 50 percent of the women and 75 percent of the men in the United States are at risk of CHD. Better estimates may be obtained using the NHANES II data (Table 2). Thus, 50 percent of the White males and at least 25 percent of the Black males ages 25 and above have ratios at or above 4.5 and would be considered at increased risk of CHD. This corresponds to population estimates of 23,877,500 White males and 1,264,500 Black males. Similarly, at least 25 percent of women, of both races, ages 25 and above would be at higher risk, corresponding to population estimates of 17,326,750 White women and 1,568,750 Black women, respectively. Thus, there are about 44 million White and Black persons in the US ages 25 to 74 who may be at higher risk of developing CHD based on a TC:HDL-C ratio of at or above 4.5. However, it must be emphasized that there is a need to describe the shape of the curve of the TC/HDL-C levels and CHD risk before selecting a reference point to obtain a reliable estimate of the population at higher risk.

The use of TC:HDL-C to predict CHD may be an oversimplification. In only one study in the US, the Framingham Study, has the predictive power of the ratio been determined. Furthermore, it is unclear whether the ratio predicts CHD across all levels of TC.[16,17] □

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Late Breaker Session on Injury Control Invites Abstracts

The Injury Control and Emergency Health Services special primary interest group of the American Public Health Association has announced it will again feature a "late breaker" session during the upcoming 119th APHA annual meeting in Atlanta. The session will be held on Tuesday, November 12, 8:30 AM–10:00 AM, and will feature work completed within the last few months—after the deadline for consideration in the regular symposia of the APHA annual meeting.

Abstracts of 250 words or fewer will be accepted by the Injury Control SPIG until September 10, 1991. Please send the abstract, title of the paper, author's name, address, and telephone number to: Richard Waxweiler, Division of Injury Control, Centers for Disease Control, Mail Stop F-36, Atlanta, GA 30333. Tel: 404/488-4695.