A Comparison of Levels of Serum Cholesterol of Adults 18-74 Years of Age in the United States in 1960-62 and 1971-74[a]

Serum cholesterol data obtained from the findings of the Health and Nutrition Examination Survey (HANES), 1971-74, present an opportunity to reexamine the level of serum cholesterol of the U.S. population aged 18-74 years.[1] Earlier determinations of serum cholesterol levels were made in the first cycle of the Health Examination Survey (HES), 1960-62, in order to provide reference data for the general population of the United States.[2] This was prompted by the epidemiologic studies associating levels of total blood cholesterol with the risk of development of coronary heart disease.[3-5]

Field data collection operations for the first HANES survey were started in April 1971 and completed in June 1974. Of the 28,043 persons aged 1-74 years who were selected in the national probability sample to represent the 194 million persons in that age group in the civilian noninstitutionalized population, 20,749, or 74.0 percent, were examined. When adjustments were made for the differential sampling ratios used for the effect of oversampling among the poor, preschool children, women of childbearing age, and the elderly, this corresponds to an effective response rate of 75 percent. Among those 18-74 years of age at interview for whom serum cholesterol determinations were made, there were 13,645 examined out of the probability sample of 19,572 selected to represent the 128 million of that age in the population. This is an unad-

justed response rate of 70 percent and an effective adjusted response of 70 percent. A detailed description of the sample and response of the Health Examination Survey of 1960-62 has been published.[6] Detailed estimates of the distribution of serum cholesterol levels will be described and analyzed in a forthcoming report in Series 11[7] of *Vital and Health Statistics*. Selected data and findings from that report on the comparison of levels of serum cholesterol in the United States in 1960-62 and 1971-74 are presented here (tables 1-3 and figures 1-4).

Figure 1. MEAN SERUM CHOLESTEROL LEVEL OF MEN 18-74 YEARS BY AGE: UNITED STATES, 1960-62 AND 1971-74
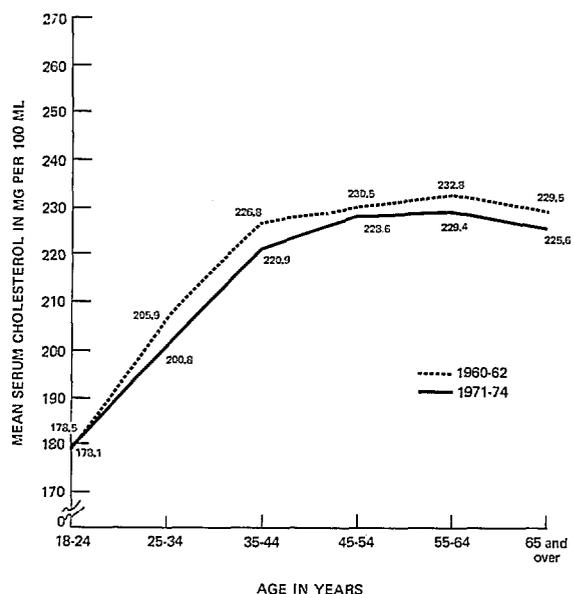
[a]This report prepared by Sidney Abraham, Clifford L. Johnson, and Margaret D. Carroll, Division of Health Examination Statistics.

CHOLESTEROL DETERMINATIONS—
HES AND HANES

Serum cholesterol determinations for HES were made using a modified ferric-chloride technique at the Lipid Standardization Laboratory of the (then) Communicable Disease Center (CDC), Public Health Service, Atlanta, Georgia. A comparative study of cholesterol methods which was conducted by CDC during the course of the Health Examination Survey determined that the ferric- sulfuric method in use was positively biased with respect to the method of Abell, Levy, Brodie, and Kendall, which was chosen as a basis of reference for its close approximation to "true" serum cholesterol values.[2] The data in the HES report presented here are therefore the original ferric-chloride values reduced by a factor of 7.6 percent to approximate Abell et al. determinations.

All serum cholesterol determinations for HANES were made in the Lipid Standardization Laboratory of what is now the Center for Disease Control, Public Health Service, Atlanta, Georgia. The analytical method was based on that of Abell et al.[8] but was modified for a semiautomated production line. The method, described in detail by Eavenson et al.[9] was made possible by the development of a relatively stable Liebermann color reagent and was designed for automatic pipetting units.

The Lipid Laboratory at the Center for Disease Control compared the results obtained with this semiautomated Abell et al. method and those obtained from their standardized version of Abell et al.[8] For examining the bias of the semiautomated method, data were obtained from pools of sera analyzed by the reference method and the semiautomated method. For pools ranging from 134 to 343 mg per 100 ml, there was in 1972 an average positive bias of 4.07 percent for the semiautomated method compared with the standard method; for the 1973-74 period, the corresponding figure was a positive bias of 4.9 percent. The weighted average bias was 4.5 percent. Therefore the data presented here are the original values produced by the semiautomated method diminished by 4.5 percent to approximate Abell et al. determinations.

Figure 2. MEAN SERUM CHOLESTEROL LEVEL OF WOMEN 18-74 YEARS BY AGE: UNITED STATES, 1960-62 AND 1971-74
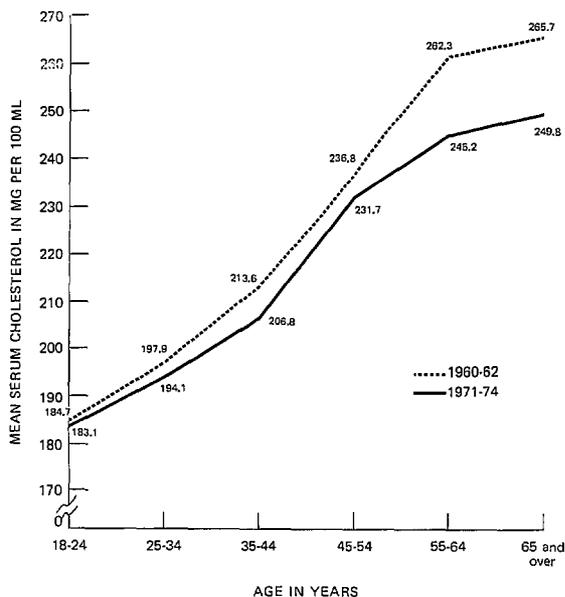
Figure 3. MEAN SERUM CHOLESTEROL LEVEL OF ADULTS 18-74 YEARS BY AGE AND SEX: UNITED STATES, 1960-62
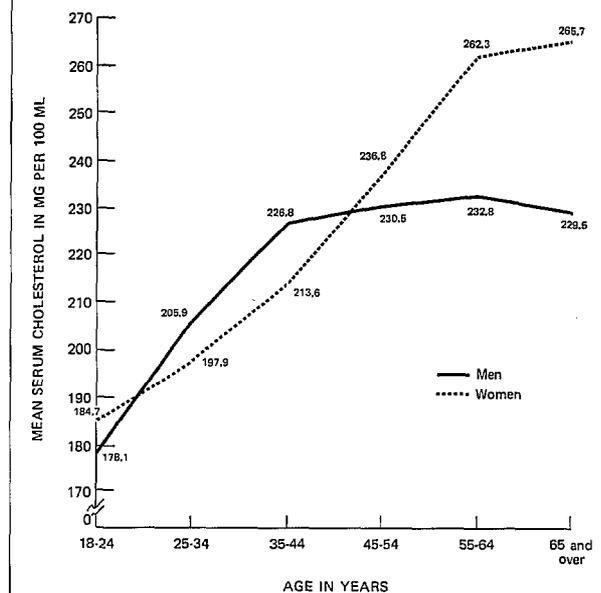
However, in the later report,[7] HANES 1971-74 serum cholesterol data will be presented without correction for bias when no comparisons are made between HANES data and the data from HES, 1960-62. Those data will thus provide population reference standards for determinations made by the semiautomated methodology now in use.

FINDINGS

Figure 1 and table 2 show that in all age groupings mean serum cholesterol levels for men in the HES sample are slightly higher than those for men in the HANES sample except for the age group 18-24 years, when the HANES sample is 0.4 mg per 100 ml higher than that for the HES sample. In other age groups the differences range from 1.9 to 5.9 mg per 100 ml, and are not significant (P>.05). The mean levels for men in both data sets increase rapidly to the age group 35-44 years and increase less rapidly to the age groups 45-54 and 55-64 years. A slight decline occurs in the age group 65-74 years.

Figure 2 and table 1 show that the mean levels for women in the HES sample are higher than the levels for women in the HANES sample in all age groups. In the age groups under 55 years, with the exception of ages 35-44 years, the differences are small, 1.6 to 5.1 mg per 100 ml, and are not significant (P>.05). In age group 35-44 and in the older age groups 55 years and over the mean levels in the HES sample are significantly higher than those in the HANES sample. The differences in mean levels are 17.1 and 15.9 mg per 100 ml, respectively, for age groups 55-64 and 65-74 years and 6.8 mg per 100 ml for the age group 35-44 years.

The mean levels for women from HES and HANES sets of data increase with age but in a slightly different· pattern. The mean levels for women in the HES sample increase to the age group 55-64 years, with the rate of increase more rapid for those in the midfifties and midsixties than for those in the earlier ages. The rate of increase then diminishes substantially, with the levels attaining a peak in the oldest age group 65-74 years. The rate of increase in the mean levels in the HANES sample show a similar pattern before age 55. However, the mean levels increase less rapidly in the midsixties, and then flatten out, with the levels also attaining a peak in the age group 65-74 years.
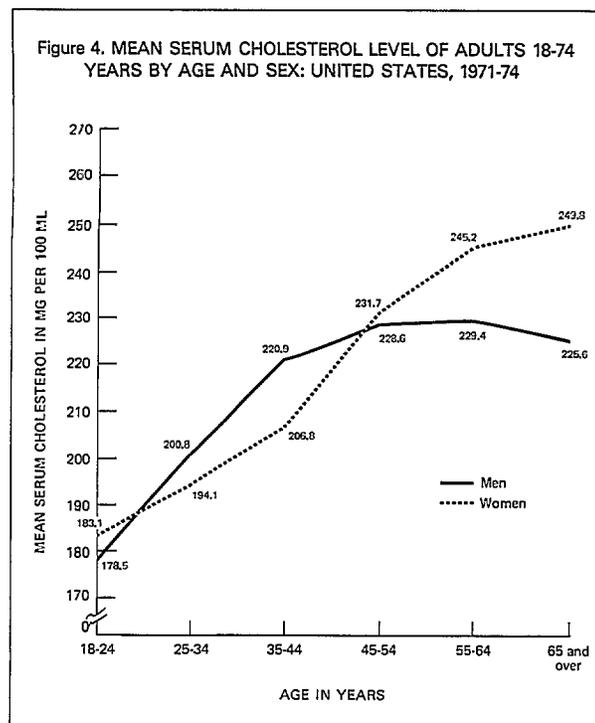
Sex Differences by Age—HES and HANES

Figure 3 shows that in the HES sample in each sex group the mean level increases with age but in different patterns. Levels for men increase rapidly to the decade 35-44 years. The rate of increase then flattens out, with levels reaching a peak in the decade 55-64 years and declining slightly thereafter. Mean levels for women are higher than those for men in the youngest age group, 18-24 years. They increase less rapidly than those for men in the midthirties and midforties but increase much more rapidly than men's levels after age 45. Thus the mean levels for women exceed those for men in the age group 45-54 years and at all ages thereafter.

Figure 4 shows the mean serum cholesterol levels in the HANES sample of adults. As in the HES sample, mean levels for women are higher than those for men in the youngest age group, 18-24 years. After age 25, the mean levels in the HANES sample generally show the same pattern as observed in the HES sample for. women and

Figure 4. MEAN SERUM CHOLESTEROL LEVEL OF ADULTS 18-74 YEARS BY AGE AND SEX: UNITED STATES, 1971-74

men. The mean levels for women increase less rapidly than those for men in the age groups 25-34 and 35-44 years but increase much more rapidly than men's levels after age 45. Here the levels for women exceed those for men in the age group 45-54 years and at all older ages. The levels for men peak at the age group 55-64 years and then decline, while the levels for women continue to rise.

A comparison of proportions of persons in HES and HANES whose serum cholesterol values exceed any specified level may be found in table 2 for men and in table 3 for women.

SUMMARY AND CONCLUSION

Prospective as well as cross-sectional epidemiologic studies associate the level of serum cholesterol with risk of developing coronary heart disease. The two surveys conducted in representative samples of the U.S. population by the National Center for Health Statistics were presented and analyzed by age and sex. They provide cross-sectional data of serum cholesterol determinations of adults obtained on different age cohorts. The age trends present the mean levels for successive cohorts of persons of different age groups reflecting the effect of environmental as well as hereditary influences. The mean level of serum cholesterol of men in each age group for the HANES sample shows a slight decrease over that obtained for the HES sample. The percent decrease in mean levels ranges from 0.8 percent in the age group 45-54 years to 2.6 percent in the age group 35-44 years.

The actual differences in means of the levels of serum cholesterol of men from the two surveys at corresponding ages are numerically small. Maximum differences are 5.9 mg per 100 ml at age 35-44 years. At other ages the HES data range from 1.9 mg per 100 ml to 5.1 mg per 100 ml greater than the HANES data.

For women in the age groups under 55 years with the exception of ages 35-44 years, the mean levels of serum cholesterol in the HANES sample show a slight decrease over the levels of the HES sample. The maximum difference is 5.1 mg per 100 ml at ages 45-54 years. At ages 18-24 and 25-34 years, the differences are 1.6 and 3.8 mg per 100 ml, respectively. The differences at ages 35-44, 55-64, and 65-74 years are 6.8, 17.1, and 15.9 mg per 100 ml. Only at these ages were the differences significant at the 0.05 level.

Both laboratory methods (1960-62 and 1971-74) show positive biases relative to a common reference method. These biases can be compared and corrected for comparisons between the 1960-62 and 1971-74 surveys. This has been done in this report. The 1971-74 data are diminished by 4.5 percent to make them comparable to the 1960-62 data which were presented already corrected by 7.6 percent to the reference method. The reference method may be presumed to be stable over time, but there were no pools of sera which were analyzed in both study periods to assure that a shift in the accuracy of this reference method did not occur because such pools are not available.

REFERENCES

[1] National Center for Health Statistics: Plan and operation of the Health and Nutrition Examination Survey, United States, 1971-1973. *Vital and Health Statistics.* Series 1-Nos. 10a and 10b. DHEW Pub. No. (HSM) 73-1310. Health Services and Mental Health Administration. Washington. U.S. Government Printing Office, Feb. 1973.

[2] National Center for Health Statistics: Serum Cholesterol Levels of Adults, United States, 1960-1962. *Vital and Health Statistics.* PHS Pub. No. 1000-Series 11-No. 22. Public Health Service. Washington. U.S. Government Printing Office, Mar. 1967.

[3] Keys, A.: The diet and plasma lipids in the etiology of coronary heart disease, in Russek, H. I., and Zohman, B. L., eds., *Coronary Heart Disease.* Philadelphia. J. B. Lippincott Co., 1971. p. 59.

[4] Keys, A., Taylor, H. L., Blackburn, H., Brozek, J., Anderson, J. T., and Simonson, E.: Coronary heart disease among Minnesota business and professional men followed fifteen years. *Circulation* 28: 381, 1963.

[5] Gordon, T., and Verter, J. I.: The Framingham Study: An epidemiological investigation of cardiovascular disease. Section 23. Serum cholesterol, systolic blood pressure, and Framingham relative weight as discrimina-

tors of cardiovascular disease. Bethesda, Md. National Institutes of Health, 1969.

[6]National Center for Health Statistics: Cycle I of the Health Examination Survey, Sample and Response, United States, 1960-1962. *Vital and Health Statistics.* PHS Pub. No. 1000-Series 11-No. 1. Public Health Service. Washington. U.S. Government Printing Office, Apr. 1964.

[7]National Center for Health Statistics: Serum cholesterol levels of adults 18-74 years, United States, 1971-74. *Vital and Health Statistics.* Series 11. Health Resources Administration, DHEW, Rockville, Md. To be published.

[8]Abell, L. L., Levy, G. B., Brodie, B. B., and Kendall, F. E.: A simplified method for the estimation of total cholesterol in serum and demonstration of its specificity. *J. Biol. Chem.* 195: 357, 1952.

[9]Eavenson, D., Grier, O. T., Cisson, J. G., and Witter, R. F.: A semiautomated procedure for the determination of serum cholesterol using the Abell-Kendall method. *J. Amer. Oil Chem. Soc.* 43: 652. 1966.

SYMBOLS	
Data not available----------------------------------	- - -
Category not applicable--------------------------	. . .
Quantity zero--	-
Quantity more than 0 but less than 0.05------	0.0
Figure does not meet standards of reliability or precision-------------------------------------	*

Table 1. Serum cholesterol level of adults aged 18-74 years by sex and age, with number of examined persons, mean, and standard deviation: United States, 1960-62 (HES) and 1971-74 (HANES)

Age	Men						Women					
	1960-62			1971-74			1960-62			1971-74		
	n^1	Mean	s^2	n^1	Mean	s^2	n^1	Mean	s^2	n^1	Mean	s^2
18-24 years..	406	178.1	40.7	772	178.5	35.0	515	184.7	47.9	1,524	183.1	39.1
25-34 years..	661	205.9	44.6	804	200.8	42.0	729	197.9	41.9	1,896	194.1	40.3
35-44 years..	691	226.8	49.4	665	220.9	43.9	762	213.6	45.3	1,663	206.8	41.5
45-54 years..	533	230.5	45.6	765	228.6	44.9	679	236.8	50.0	836	231.7	49.6
55-64 years..	410	232.8	49.0	597	229.4	48.9	426	262.3	63.0	670	245.2	46.0
65-74 years..	262	229.5	47.3	1,657	225.6	51.3	289	265.7	58.8	1,822	249.8	49.6

[1]n denotes number of examined persons.
[2]s denotes standard deviation.

NOTE: The distribution of the number of persons examined by age and sex is different for HES and HANES because different sampling rates were applied to the subgroups, but within subgroups sampling rates are representative of the U.S. population at the time of the survey.

Table 2. Cumulative percent distribution of serum cholesterol levels of adult males by age: United States, 1960-62 (HES) and 1971-74 (HANES)

Serum cholesterol level (mg/100ml)	18-74 years		18-24 years		25-34 years		35-44 years		45-54 years		55-64 years		65-74 years	
	1960-62	1971-74	1960-62	1971-74	1960-62	1971-74	1960-62	1971-74	1960-62	1971-74	1960-62	1971-74	1960-62	1971-74
	Cumulative percent distribution													
Under 100	0.1	0.2	0.4	0.1	-	0.1	0.1	-	-	0.7	0.2	0.1	-	0.2
Under 120	0.8	0.9	2.9	2.4	0.6	1.1	0.6	0.1	0.1	0.7	0.7	0.1	-	0.7
Under 140	3.3	4.1	14.4	11.8	2.6	4.1	1.5	1.7	0.3	1.4	1.5	1.7	1.3	2.7
Under 160	9.6	12.2	33.1	31.1	10.2	14.7	5.3	6.2	3.7	6.0	4.4	3.3	4.1	6.2
Under 180	21.2	25.7	57.9	55.1	27.5	32.7	14.1	17.6	9.4	11.8	11.1	12.4	10.3	14.6
Under 200	35.7	42.3	73.8	76.6	47.7	53.6	25.4	32.8	22.6	24.2	22.1	24.2	26.5	29.8
Under 220	53.4	59.0	86.8	87.5	66.5	70.8	45.8	51.6	42.6	41.8	36.4	42.9	43.3	47.9
Under 240	70.4	74.5	93.6	94.1	81.4	84.3	66.1	68.5	60.8	62.6	58.3	63.2	62.0	65.5
Under 260	82.4	85.3	96.1	97.2	89.6	91.8	79.8	82.9	74.3	75.9	76.5	79.8	78.4	79.1
Under 280	90.6	91.8	99.1	98.6	95.5	96.3	88.3	90.0	86.3	86.4	87.8	87.3	86.7	88.8
Under 300	95.3	95.9	99.4	99.8	98.0	97.9	93.0	93.8	94.7	94.4	93.0	93.3	93.9	94.3
Under 320	97.9	97.8	99.6	99.8	99.8	98.7	96.9	97.8	98.6	96.5	96.4	96.2	96.5	96.9
Under 340	98.9	99.0	99.8	100.0	99.8	99.0	97.9	99.3	99.4	98.9	98.6	97.9	98.3	97.8
Under 360	99.4	99.4	99.8	100.0	99.8	99.4	99.0	99.4	99.9	99.7	99.1	98.8	98.9	98.9
Under 380	99.6	99.6	99.8	100.0	99.8	99.4	99.6	99.7	99.9	100.0	99.3	99.1	99.5	99.1

Table 3. Cumulative percent distribution of serum cholesterol levels of adult females by age: United States, 1960-62 (HES) and 1971-74 (HANES)

Serum cholesterol level (mg/100ml)	18-74 years		18-24 years		25-34 years		35-44 years		45-54 years		55-64 years		65-74 years	
	1960-62	1971-74	1960-62	1971-74	1960-62	1971-74	1960-62	1971-74	1960-62	1971-74	1960-62	1971-74	1960-62	1971-74
	Cumulative percent distribution													
Under 100	0.1	0.2	0.3	0.4	-	0.6	-	0.3	-	-	-	-	0.3	-
Under 120	0.8	1.1	2.9	2.9	0.8	1.6	0.6	0.7	-	0.3	-	0.1	0.7	0.6
Under 140	2.8	4.5	9.2	11.5	4.4	7.1	1.8	3.2	0.6	0.7	-	0.4	1.1	1.7
Under 160	9.3	12.3	28.3	28.9	15.1	17.4	6.5	11.0	2.7	4.8	0.1	2.7	1.5	3.1
Under 180	20.9	24.3	49.4	49.7	33.8	36.3	19.6	23.5	7.9	11.6	3.5	6.3	6.0	6.0
Under 200	35.2	41.4	69.8	69.5	55.8	60.4	38.3	46.3	18.1	25.7	7.7	15.3	8.8	13.0
Under 220	51.9	57.9	84.9	83.5	74.5	77.5	62.1	67.0	35.0	43.7	17.9	29.8	17.6	24.9
Under 240	64.9	71.8	91.0	92.1	86.5	88.3	76.8	80.7	53.0	61.8	29.9	47.3	31.4	42.5
Under 260	77.3	82.5	95.4	97.0	92.6	94.4	87.1	90.4	72.0	75.5	50.3	64.7	49.0	59.3
Under 280	85.5	89.4	97.5	97.9	95.7	97.5	93.0	94.7	84.7	85.0	64.1	76.9	64.8	76.0
Under 300	91.8	94.3	98.2	99.3	98.6	98.8	97.1	97.8	93.7	90.8	79.1	88.1	73.3	86.1
Under 320	95.4	97.1	99.0	99.8	99.3	99.1	98.4	98.9	96.3	95.3	88.3	94.4	84.7	92.2
Under 340	97.8	98.2	99.7	99.8	99.6	99.7	98.9	99.5	98.6	96.5	95.3	96.4	91.8	96.2
Under 360	98.8	99.2	99.9	99.8	99.7	99.8	99.3	99.6	99.5	98.4	98.3	98.9	94.2	98.3
Under 380	99.4	99.5	99.9	99.9	99.9	99.8	99.5	99.7	99.6	99.0	99.6	99.4	97.0	99.1

TECHNICAL NOTES

The sampling plan for the 65 preselected examination locations in the Health and Nutrition Examination Survey followed a highly stratified multistage probability design in which a sample of the civilian, noninstitutionalized population of the conterminous United States 1 to 74 years of age was selected. Successive elements dealt with in the process of sampling were the primary sampling unit, census enumeration district, segment (a cluster of households), household, eligible person, and sample person. The sampling design provided for oversampling among persons living in poverty areas, preschool children, women of childbearing age, and the elderly.

The serum cholesterol determinations are shown as population estimates, that is, the serum cholesterol findings for each individual have been "weighted" by the reciprocal of the probability of selecting the person. An adjustment for persons in the sample who were not examined and poststratified ratio adjustments were also made and so the final sampling estimates of the population size agree exactly with the U.S. Bureau of the Census independent estimates for the civilian, noninstitutionalized population of the United States as of November 1, 1972, by race, sex, and age.

Previous issues of *Advance Data From Vital and Health Statistics*

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