Joint Distribution of Lipoprotein Cholesterol Classes

The Framingham Study

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During the period 1971 to 1975, the cholesterol content of lipoprotein density classes were measured in 2415 male and female Framingham Heart Study participants and 4342 of their offspring and offspring spouses who were free of coronary heart disease. In this first of three papers, the univariate and bivariate distributions of high density lipoprotein cholesterol, low density lipoprotein cholesterol, and very low density lipoprotein cholesterol are presented. There are differences in the levels of lipoprotein cholesterols by age, gender, and use of hormone preparations. The bivariate cross-tabulations of the three pairs of lipoprotein cholesterol measurements exhibit properties that cannot be appreciated from univariate summary statistics and suggest the importance of joint consideration of different lipoprotein cholesterol patterns for assessing the risk of coronary heart disease.
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It has become increasingly evident that the content and function of lipoprotein particles is intimately involved in atherogenesis and, therefore, the pathology of the major vascular diseases. Along with initiatives in the basic biology of lipoproteins, there have been major efforts to measure lipoproteins in large samples and to pursue the descriptive epidemiology of lipoproteins, their concomitants, and their role in atherogenesis. The measurement of blood lipids is now an essential component of prospective cardiovascular disease studies. In the original Framingham cohort which has been followed since 1949, total serum cholesterol was determined early in the study and was shown to be an important risk factor.[1] In the 1950s, flotation fractionation of lipoproteins was developed.[2] This method allowed investigation of lipoproteins of different densities and identified the elevations of low density lipoproteins as being particularly associated with coronary heart disease (CHD). At this time, the risk connected with low levels of high-density lipoproteins was also discovered but went into eclipse for some 20 years. In the 1960s, new methods of ultracentrifugation permitted chemical analysis of the various lipoprotein fractions[3] leading to the measurement of the cholesterol content of low density lipoprotein, high density lipoprotein, and very low density lipoprotein.

The first descriptions of lipoprotein cholesterol distributions came from large cross-sectional surveys in populations and clinic patients. Recently, the Lipid Research Clinics (LRC) screening program has investigated lipoprotein cholesterol values in large and diverse samples.[4]

During the period 1971 to 1975, lipid determinations were made on 2415 males and females in the original Framingham Cohort aged 50 to 79 years, and in 4342 of their offspring and spouses aged 15 to 49 years. The comprehensive history and physical examinations performed on Framingham Heart Study participants, the lipid determinations in family members whose ages span six decades, and the provisions for follow-up, provide unique opportunities for the study of lipoprotein cholesterols and their relation to disease.

This report will present various aspects of the lipoprotein cholesterol data in Framingham with particular emphasis on the univariate characteristics and joint distributions of the various lipoprotein cholesterols. A second manuscript will deal with the multivariate associations between various personal and environmental factors and lipoprotein cholesterols observed in the Framingham sample. A final report will summarize the overall importance of lipoprotein

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cholesterol measurement, and its role in the prediction of morbidity and mortality from coronary heart disease.

Methods

The abbreviated term "lipoprotein cholesterol" in this presentation describes cholesterol levels in high density (HDL-C), low density (LDL-C), and very low density (VLDL-C) lipoproteins. Levels of HDL-C were measured after precipitation of LDL-C and VLDL-C with heparin manganese-chloride.[5] The bottom fraction containing LDL-C was measured following reconstitution of EDTA plasma at serum density after preparative ultracentrifugation. LDL-C was calculated by subtracting HDL-C from cholesterol contained in the bottom fraction. VLDL-C was measured by subtracting the bottom fraction cholesterol from total cholesterol. If this difference was a negative value, it was arbitrarily set at zero. All cholesterol measurements were made by the manual Abell-Kendall method.[6] The measurements are presented only for individuals free of CHD[7] at the time of the lipoprotein cholesterol measurements. Women designated as "hormone users" fall into two categories: premenopausal women who used combination estrogen-progestogen preparations, and post-menopausal women using conjugated estrogens alone.

Results

The mean and percentile values of HDL-C, LDL-C, and VLDL-C are given in Tables 1 to 3. The data are stratified by gender and 5-year age groups. Women

Table 1. Mean and Percentiles of HDL-C (mg/dl) by Age, Gender, and Hormone Use

Age (yrs)	No.	Mean	STD	Percentiles 5th	10th	50th	90th	95th
Females not using estrogen hormones								
15–19	75	52.29	12.25	33.00	35.60	51.00	69.00	74.20
20–24	160	54.76	12.03	35.05	39.10	54.00	70.90	76.00
25–29	322	55.04	13.00	35.15	39.00	54.00	74.00	77.00
30–34	366	56.14	13.03	34.35	40.00	56.00	73.29	79.64
35–39	303	56.27	13.91	36.00	39.00	55.00	73.59	83.39
40–44	336	57.09	15.26	34.85	39.70	55.00	78.00	84.00
45–49	274	57.58	15.64	36.00	39.00	55.00	79.50	89.24
50–54	293	59.81	16.35	34.00	40.40	58.00	82.00	88.29
55–59	316	58.11	16.17	33.00	39.00	56.00	79.00	85.14
60–64	267	57.18	15.92	35.40	40.80	55.00	78.00	87.00
65–69	179	57.23	14.55	34.00	40.00	56.00	76.00	82.00
70–74	159	55.77	15.71	35.00	38.00	53.00	76.00	84.00
75–79	97	53.54	12.24	33.80	38.80	54.00	71.00	73.59
Females using estrogen hormones								
15–19	12	49.25	11.90	26.00	29.30	48.00	67.20	69.00
20–24	71	52.32	13.09	32.80	38.00	52.00	68.80	79.00
25–29	110	54.92	13.77	31.55	37.10	54.00	74.00	80.45
30–34	88	53.35	15.17	30.45	36.00	52.00	72.10	80.65
35–39	54	59.22	17.96	33.50	40.50	54.50	84.50	101.25
40–44	41	59.58	13.43	32.10	42.60	60.00	74.60	84.60
45–49	54	64.98	19.23	32.00	41.00	63.00	89.49	100.50
50–54	16	58.06	16.16	34.00	36.10	55.50	83.90	86.00
55–59	26	57.50	14.98	33.75	37.70	57.00	80.60	85.90
60–64	12	52.41	6.31	40.00	41.50	53.50	60.00	60.00
65–69	20	54.00	14.42	28.30	34.60	52.00	75.00	78.80
70–74	14	55.50	15.68	35.00	36.00	54.50	81.50	92.00
75–79	7	57.71	14.44	38.00	38.00	54.00	82.00	82.00
Males								
15–19	92	45.45	11.67	28.95	31.30	44.00	65.00	68.35
20–24	168	45.41	9.93	31.00	32.90	44.50	59.10	63.10
25–29	369	44.02	11.34	28.00	31.00	43.00	59.00	64.99
30–34	406	44.01	11.55	27.00	30.00	42.00	59.00	64.00
35–39	376	43.56	11.27	27.85	31.00	42.00	59.00	64.00
40–44	356	43.57	11.48	29.00	31.00	42.00	58.29	66.00
45–49	309	45.03	13.09	29.00	31.00	42.00	62.00	68.49
50–54	238	45.21	11.50	28.00	31.00	44.00	61.00	66.10
55–59	243	45.31	13.78	26.20	30.00	44.00	61.00	68.80
60–64	184	47.11	13.87	29.00	32.00	44.50	66.00	73.00
65–69	148	45.41	13.87	27.00	31.00	43.00	59.30	67.55
70–74	125	45.66	10.64	31.00	34.00	44.00	59.00	66.70
75–79	71	48.45	18.50	27.00	29.20	44.00	79.80	91.39

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using and not using hormones containing estrogen at the time of testing are described separately. Comparing men with women, we found that HDL-C levels were always lower in men than women, irrespective of hormone use. For LDL-C, women users and nonusers of hormones had lower levels than men in their twenties up to about age 50; in the teens and after menopause, the pattern tended to reverse, with women having higher levels than men. VLDL-C was higher in men than women in most age groups, regardless of estrogen hormone use; the exceptions that occurred may represent random variation around the predominant pattern of higher VLDL-C values among men.

Comparing women who use and do not use hormones with estrogen, we found that the pattern with regard to HDL-C is not clear. There was a tendency for nonusers to have higher levels than users, holding for a total span of 45 out of the total of 65 years; the reverse pattern was seen, however, in the entire forties and two 5-year age groups in the fifties and seventies. The trends were not entirely consistent for LDL-C either, although there was a tendency toward lower levels in nonusers. Women not using hormones clearly had lower levels of VLDL-C than users up to age 60, except in the teenage years.

Cross tabulations of the data given in Tables 1 to 3 are provided in Figures 1 to 6. The figures depict bivariate relationships among HDL-C, LDL-C, and VLDL-C by gender and 10-year age group (ages 20 to 79 years). Women receiving estrogen hormone therapy are not included in any of the tabulations.

Table 2. Mean and Percentiles of LDL-C (mg/dl) by Age, Gender, and Hormone Use

Age (yrs)	No.	Mean	STD	Percentiles 5th	10th	50th	90th	95th
Females not using estrogen hormones								
15–19	75	100.44	21.48	69.40	72.60	98.00	129.40	146.40
20–24	160	100.83	25.81	66.10	75.00	98.00	128.00	148.90
25–29	322	110.14	29.80	68.15	75.00	106.00	149.00	167.00
30–34	366	110.81	28.66	72.00	77.00	108.00	146.00	161.30
35–39	303	115.34	32.92	71.20	78.00	110.00	160.60	174.00
40–44	336	122.83	32.35	76.40	85.00	120.00	165.00	179.00
45–49	274	133.13	35.04	84.75	90.50	128.00	181.00	199.25
50–54	293	142.89	37.33	89.00	99.00	142.00	191.60	207.00
55–59	316	156.15	37.97	102.00	111.70	150.50	205.30	231.15
60–64	267	159.16	38.03	99.00	110.60	157.00	205.20	226.20
65–69	179	159.60	40.55	95.00	108.00	101.00	212.00	228.00
70–74	159	157.07	35.85	99.00	113.00	156.00	198.00	224.00
75–79	97	156.91	39.63	99.50	113.80	147.00	220.20	236.50
Females using estrogen hormones								
15–19	12	118.08	28.76	92.00	92.60	106.00	166.60	169.00
20–24	71	111.71	37.12	61.80	68.20	110.00	141.20	189.00
25–29	110	110.56	30.35	61.30	77.20	109.00	145.60	161.90
30–34	88	116.40	31.79	64.35	82.80	115.50	164.30	173.00
35–39	54	116.88	30.54	61.00	75.00	116.00	164.50	169.25
40–44	41	128.41	41.43	74.10	85.40	125.00	181.20	216.40
45–49	54	128.75	32.39	80.75	93.50	122.50	168.50	186.25
50–54	16	172.93	51.64	81.00	101.30	164.50	255.60	271.00
55–59	26	164.50	31.42	101.55	112.10	166.50	204.00	224.65
60–64	12	159.08	41.14	104.00	104.30	154.00	230.20	241.00
65–69	20	159.15	44.03	78.60	109.10	152.00	234.10	239.80
70–74	14	162.50	40.25	97.00	103.50	158.50	234.50	241.00
75–79	7	169.00	19.49	143.00	143.00	173.00	192.00	192.00
Males								
15–19	92	97.08	26.22	64.65	69.30	91.00	130.10	149.35
20–24	168	111.92	27.56	71.45	80.00	107.00	149.10	160.65
25–29	369	120.86	29.76	75.00	83.00	120.00	156.00	166.50
30–34	406	128.52	34.10	81.35	88.00	126.00	173.30	184.30
35–39	376	135.44	33.05	84.00	94.40	134.00	179.30	196.15
40–44	356	140.07	31.70	87.85	99.00	140.00	181.30	193.30
45–49	309	142.68	37.01	91.00	97.00	141.00	184.00	204.00
50–54	238	145.08	37.80	85.00	97.00	145.50	194.00	210.05
55–59	243	141.50	40.69	80.40	93.00	140.00	194.80	211.20
60–64	184	143.98	34.88	91.00	99.50	142.00	194.50	214.00
65–69	148	141.66	35.16	84.45	96.90	139.00	188.10	202.00
70–74	125	139.95	35.54	84.00	91.60	139.00	183.80	198.00
75–79	71	132.25	36.29	77.20	84.00	133.00	181.60	206.60

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Within each cell of a figure is the observed percentage of Framingham participants in that gender- and age-specific group who have lipoprotein cholesterol levels within the range of values indicated at the top and to the left of the cell. In several instances, percentages within a table do not add up to 100. This results from errors in rounding off numbers and the fact that a few members of the sample exceed the range of values specified in the figures. As a result, the tables do not include all combinations of observed lipoprotein cholesterol characteristics (less than 2% are not presented). Nevertheless, all percentages and total numbers specified within a table are based on the entire sample, comprising even those persons whose lipoprotein cholesterol levels are not included in a figure.

Shades of gray in Figures 1 to 6 illustrate a cumulative percentage distribution; the darker shades represent the most commonly occurring combinations of lipoprotein cholesterol levels. The shading provided is not exact but approximates percentiles of individuals possessing certain lipoprotein cholesterol characteristics. The key at the bottom of each figure describes four shades of gray. The darkest shade represents the most common combinations of lipoprotein cholesterol levels and characterizes the cells comprising approximately 50% of the sample. The medium dark shade represents the next 25% most common combinations of lipoprotein cholesterol levels of the sample. The cells represented by the darkest and medium dark shades of gray represent a cumulative 75% of the sample. Inclusion of the re-

Table 3. Mean and Percentiles of VLDL-C (mg/dl) by Age, Gender, and Hormone Use

Age (yrs)	No.	Mean	STD	Percentiles 5th	10th	50th	90th	95th
Females not using estrogen hormones								
15–19	75	12.64	7.39	1.00	2.00	12.00	22.40	27.00
20–24	160	13.76	8.22	3.00	4.10	13.00	25.90	29.00
25–29	322	13.16	7.75	2.00	4.30	12.00	22.00	26.84
30–34	366	13.37	8.56	2.00	4.00	12.00	23.00	28.64
35–39	303	15.92	10.77	3.00	5.00	14.00	27.59	35.00
40–44	336	17.74	15.71	4.00	6.00	15.00	29.59	38.14
45–49	274	19.40	14.11	3.75	6.50	17.00	34.50	43.49
50–54	293	26.23	19.15	5.70	8.00	21.00	47.59	61.29
55–59	316	26.52	20.13	4.00	6.70	22.00	49.00	65.00
60–64	267	27.62	18.95	6.00	8.80	24.00	49.20	66.80
65–69	179	29.12	16.08	9.00	12.00	27.00	49.00	59.00
70–74	159	32.47	20.18	9.00	10.00	30.00	54.00	70.00
75–79	97	28.87	19.58	4.00	8.80	26.00	48.20	66.10
Females using estrogen hormones								
15–19	12	11.50	7.00	3.00	3.00	10.00	21.00	21.00
20–24	71	18.57	8.59	4.00	7.00	18.00	30.80	35.00
25–29	110	16.10	9.39	4.00	6.00	15.00	29.00	33.00
30–34	88	17.75	10.25	4.45	6.90	16.50	28.20	43.84
35–39	54	21.11	12.02	2.50	5.00	21.00	38.99	45.25
40–44	41	22.90	15.39	8.30	12.00	19.00	35.40	48.99
45–49	54	20.01	11.41	3.00	6.00	20.00	36.00	42.49
50–54	16	27.12	10.95	15.00	15.70	24.50	49.90	52.00
55–59	26	31.30	18.15	3.80	11.10	27.00	58.09	68.84
60–64	12	28.00	17.69	8.00	9.20	24.00	64.50	75.00
65–69	20	30.20	19.63	10.10	12.00	24.50	69.59	82.45
70–74	14	29.71	14.12	9.00	10.00	29.50	54.50	55.00
75–79	7	21.28	11.48	10.00	10.00	17.00	41.00	41.00
Males								
15–19	92	15.76	9.32	3.65	5.00	14.50	27.00	30.70
20–24	168	18.29	10.26	6.00	7.00	16.00	32.10	39.00
25–29	369	20.83	14.93	6.00	8.00	18.90	37.00	46.99
30–34	406	23.66	18.25	5.00	7.00	19.00	48.29	59.64
35–39	376	25.47	18.55	6.00	9.00	22.00	46.00	56.00
40–44	356	28.17	21.20	7.00	9.00	22.00	52.29	64.00
45–49	309	30.66	23.78	7.00	11.00	25.00	54.00	68.49
50–54	238	32.76	22.19	7.00	10.90	28.00	63.10	87.00
55–59	243	32.80	27.42	7.20	11.00	26.00	60.80	79.20
60–64	184	28.19	17.36	6.25	9.50	26.00	49.50	54.75
65–69	148	33.76	27.62	8.45	11.00	29.00	57.00	62.20
70–74	125	28.72	18.75	7.00	10.60	26.00	45.00	66.30
75–79	71	29.07	22.77	6.80	8.20	25.00	46.80	68.59

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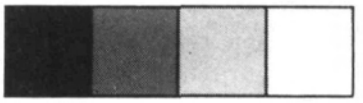

50 75 95 100

AGED 20–29

LDL-C (mg dl)

HDL-C (mg dl)	10-29	30-49	50-69	70-89	90-109	110-129	130-149	150-169	170-189	190-209	210-229	230-249	250-269	TOTAL %
10-19				0.37		0.19								0.56
20-29				0.93	1.68	1.68	0.93	0.37	0.19					5.77
30-39		0.19	0.93	2.42	8.75	6.70	6.52	1.30	0.19	0.19				27.19
40-49		0.19	2.23	7.64	8.94	8.94	6.33	2.05	0.93					37.43
50-59		0.56	1.86	4.86	6.15	3.54	1.68	0.56	0.37	0.19				19.55
60-69		0.19	0.93	2.23	1.30	1.49	0.37	0.37						6.89
70-79			0.19	0.74	0.56		0.56							2.05
80-89		0.19	0.37											0.56
90-99														
100-109														
110-119														
TOTAL %		1.30	6.52	18.99	27.37	22.53	16.39	4.66	1.68	0.37				N = 537

AGED 30–39

LDL-C (mg dl)

HDL-C (mg dl)	10-29	30-49	50-69	70-89	90-109	110-129	130-149	150-169	170-189	190-209	210-229	230-249	250-269	TOTAL %
10-19				0.13				0.13						0.26
20-29	0.13		0.26	3.90	2.05	1.92	1.41	0.90	0.51		0.13			8.18
30-39		0.13	1.15	3.07	5.37	7.16	6.65	3.32	2.30	0.38	0.64			30.31
40-49			0.64	3.20	7.42	9.59	7.80	2.69	1.79	0.64	0.13			33.89
50-59		0.26	0.51	2.56	4.09	4.73	3.07	1.79	0.77	0.64	0.13			18.54
60-69			0.51	1.28	0.90	1.53	0.64	0.51	0.13		0.13			5.63
70-79	0.13	0.13	0.13	1.02	0.51	0.38	0.38	0.13						2.81
80-89			0.13		0.13				0.13					0.38
90-99														
100-109														
110-119														
TOTAL %	0.26	0.51	3.32	12.15	20.46	25.32	19.95	9.46	5.63	1.66	1.15			N = 782

AGED 40–49

LDL-C (mg dl)

HDL-C (mg dl)	10-29	30-49	50-69	70-89	90-109	110-129	130-149	150-169	170-189	190-209	210-229	230-249	250-269	TOTAL %
10-19							0.15							0.15
20-29		0.15		0.60	1.20	1.88	0.90	0.75	0.15	0.15	0.15	0.30		6.17
30-39			0.45	2.25	3.91	8.72	8.87	3.51	4.21	0.90	0.30		0.15	33.53
40-49			0.45	2.41	4.96	6.32	10.23	6.02	1.95	0.60	0.45			33.38
50-59		0.15	0.30	1.65	2.56	4.36	3.61	1.95	1.35	0.15	0.30	0.15		16.54
60-69			0.15	1.05	0.90	1.65	1.50	0.90	0.15	0.15				6.47
70-79			0.15	0.60	0.45	0.60	0.45			0.30				2.56
80-89				0.15	0.15	0.15	0.15			0.15				0.75
90-99						0.15								0.15
100-109														0.30
110-119			0.15	0.15										
TOTAL %		0.30	1.65	8.87	14.14	23.76	25.86	13.23	7.82	2.41	1.20	0.45	0.15	N = 665

AGED 50–59

LDL-C (mg dl)

HDL-C (mg dl)	10-29	30-49	50-69	70-89	90-109	110-129	130-149	150-169	170-189	190-209	210-229	230-249	250-269	TOTAL %
10-19						0.21	0.21							0.42
20-29	0.21		0.62	0.83	1.66	1.46	1.87	0.21	0.21		0.21			7.48
30-39	0.21	0.42	0.83	2.29	2.49	4.37	6.44	5.20	2.49	1.46	0.42			26.61
40-49			0.42	2.08	3.74	6.44	8.32	4.37	3.74	1.25	0.42			30.77
50-59	0.21			1.87	2.91	4.99	4.57	3.33	1.87	1.87	0.83	0.21	0.21	23.08
60-69			0.42	1.25	1.46	2.08	0.83	0.83	0.62	0.21	0.21			7.90
70-79			0.21	0.62	0.62	0.21		0.83						2.49
80-89			0.21	0.21										0.42
90-99								0.21				0.21		0.42
100-109			0.21		0.21									0.42
110-119														
TOTAL %	0.62	0.42	2.91	9.15	13.10	19.75	22.25	14.97	8.94	4.78	2.08	0.42	0.21	N = 481

AGED 60–69

LDL-C (mg dl)

HDL-C (mg dl)	10-29	30-49	50-69	70-89	90-109	110-129	130-149	150-169	170-189	190-209	210-229	230-249	250-269	TOTAL %
10-19					0.30									0.30
20-29			1.51	0.30	1.20	1.81	1.51				0.30			6.63
30-39			0.60	2.41	2.11	7.83	6.33	2.71	1.51	1.20	0.60			25.30
40-49			0.30	1.81	4.82	5.12	5.42	6.93	3.61	3.61	0.90			32.53
50-59			0.30	1.20	3.92	5.72	6.93	2.41	2.41	0.60				23.49
60-69			0.30	0.60	1.51	1.81	0.30	0.30	0.90	0.30				6.02
70-79				0.60	0.30	0.60	1.51							3.01
80-89			0.30			0.60								0.90
90-99				0.30	0.30	0.30		0.30						1.20
100-109				0.30										0.30
110-119														0.30
TOTAL %			3.31	7.53	14.76	23.80	21.99	12.65	8.43	5.72	1.81			N = 332

AGED 70–79

LDL-C (mg dl)

HDL-C (mg dl)	10-29	30-49	50-69	70-89	90-109	110-129	130-149	150-169	170-189	190-209	210-229	230-249	250-269	TOTAL %
10-19														
20-29				0.51	2.04	1.53	0.51	0.51						5.10
30-39			0.51	3.06	4.08	7.14	6.12	5.10	1.53	1.02		0.51	0.51	29.59
40-49		1.53	0.51	3.57	2.55	7.14	8.67	3.06	3.06	0.51	0.51			31.12
50-59				2.55	2.55	7.14	3.06	3.57	1.02	1.53				21.43
60-69			0.51	2.04	0.51	2.55	1.53							7.14
70-79						0.51			0.51					1.02
80-89				0.51	0.51	0.51	0.51	1.02						3.06
90-99				0.51										0.51
100-109			0.51			0.51								1.02
110-119														
TOTAL %		1.53	2.04	12.76	12.24	27.04	20.41	13.27	6.12	3.06	0.51	0.51	0.51	N = 196

Figure 1. Percentage distribution of HDL-C and LDL-C for males.

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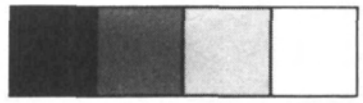
CUMULATIVE PERCENT DISTRIBUTION



LDL-C (mg/dl)

HDL-C (mg/dl)	10-29	30-49	50-69	70-89	90-109	110-129	130-149	150-169	170-189	190-209	210-229	230-249	250-269	TOTAL %
10-19														
20-29				0.41	0.41		0.21	0.21		0.21				1.45
30-39		0.41	0.83	1.87	2.90	1.04	1.04	0.41	0.21					8.71
40-49			3.63	6.64	7.68	4.36	2.07	0.41	0.41	0.41				25.52
50-59		0.82	2.63	10.58	10.17	3.73	1.87	0.83	0.41					31.74
60-69		0.82	3.11	4.98	5.60	2.90	0.82	0.21	0.41	0.62				19.09
70-79		0.21	0.62	2.28	3.11	2.28	0.83							9.34
80-89		0.21	0.41	1.24	0.41	1.04		0.21						3.53
90-99				0.41		0.21								0.62
100-109														
110-119														
TOTAL %		2.07	12.03	28.42	30.29	15.56	6.64	2.28	1.45	1.24				N = 482

AGED 20–29

LDL-C (mg/dl)

HDL-C (mg/dl)	10-29	30-49	50-69	70-89	90-109	110-129	130-149	150-169	170-189	190-209	210-229	230-249	250-269	TOTAL %
10-19						0.15								0.15
20-29			0.30		0.45	0.45	0.15	0.15				0.15		1.64
30-39			0.30	1.35	2.09	1.94	1.64	0.45	0.30					7.77
40-49		0.15	1.20	4.33	5.68	5.08	2.99	1.64	1.05	0.30				22.42
50-59	0.15	0.45	2.54	8.67	8.07	5.38	1.79	1.79	0.45		0.15	0.15		29.60
60-69		0.60	2.24	6.43	8.07	4.04	1.35	0.60					0.15	23.47
70-79		0.30	1.64	3.44	1.64	1.35	1.05	0.30						9.72
80-89		0.15	0.45	0.90	1.35	0.60	0.15	0.15						3.74
90-99	0.15		0.30	0.45	0.30									1.20
100-109				0.15	0.15									0.30
110-119														
TOTAL %	0.30	1.64	8.97	25.71	27.80	18.68	9.12	5.08	1.79	0.30	0.15	0.30	0.15	N = 669

AGED 30–39

LDL-C (mg/dl)

HDL-C (mg/dl)	10-29	30-49	50-69	70-89	90-109	110-129	130-149	150-169	170-189	190-209	210-229	230-249	250-269	TOTAL %
10-19														
20-29					0.33		0.49	0.33						1.15
30-39		0.33	0.33	1.15	1.48	3.11	1.31	0.66	0.49	0.16	0.16			9.18
40-49		0.16	0.33	2.46	4.59	7.38	2.95	2.46	0.98	1.15		0.16	0.16	22.79
50-59	0.16	0.33	0.66	3.44	7.87	7.05	4.43	2.95	1.31	0.82		0.16		29.18
60-69		0.33	0.33	2.62	5.08	4.10	3.44	1.15	0.49			0.16	0.16	17.87
70-79		0.33	0.82	2.30	2.30	2.30	1.80	0.49	0.49	0.16				10.98
80-89			0.16	1.31	2.13	0.82	0.49	0.49						5.41
90-99			0.16	0.33	0.66	1.15								2.30
100-109			0.16	0.16		0.16								0.49
110-119		0.16		0.16	0.33									0.66
TOTAL %	0.16	1.64	2.95	13.93	24.75	26.07	14.92	8.52	3.77	2.30	0.16	0.49	0.33	N = 610

AGED 40–49

LDL-C (mg/dl)

HDL-C (mg/dl)	10-29	30-49	50-69	70-89	90-109	110-129	130-149	150-169	170-189	190-209	210-229	230-249	250-269	TOTAL %
10-19														
20-29						0.49	0.16	0.33	0.16		0.16		0.16	1.48
30-39			0.16	0.33	1.15	2.63	1.97	0.66	0.16	0.49	0.33	0.16		8.21
40-49				1.15	2.13	4.11	4.27	4.11	1.97	2.13	0.49	0.16		20.69
50-59				0.82	2.46	4.76	6.73	4.76	3.94	0.99	0.49	0.33		25.45
60-69	0.16	0.16		0.49	1.64	6.08	4.60	3.94	1.64	0.99	0.66			20.53
70-79			0.49	1.48	1.81	3.12	1.97	0.99	1.81	0.33	0.49	0.33		12.81
80-89	0.16		0.33	0.82	1.48	1.64	1.31	0.66	0.99	0.16				7.55
90-99				0.49	0.33	0.33	0.33	0.16	0.16					1.81
100-109					0.33	0.33								0.66
110-119				0.16		0.33	0.16							0.66
TOTAL %	0.33	0.16	0.99	5.75	11.33	23.81	21.67	15.60	10.84	5.09	2.63	0.99	0.16	N = 609

AGED 50–59

LDL-C (mg/dl)

HDL-C (mg/dl)	10-29	30-49	50-69	70-89	90-109	110-129	130-149	150-169	170-189	190-209	210-229	230-249	250-269	TOTAL %
10-19														
20-29				0.22			0.45	0.22	0.45			0.22		1.57
30-39		0.22			0.90	0.90	1.35	1.12	1.57	0.67	0.45	0.22	0.22	7.85
40-49		0.22	0.22	0.67	1.35	1.57	5.38	6.28	4.26	2.02	1.12		0.22	23.32
50-59				0.90	3.36	4.71	6.50	5.16	5.16	2.69	1.57	0.45	0.22	30.72
60-69		0.22	0.22	0.90	2.24	2.24	3.59	3.14	2.47	1.35	0.22	0.45		17.04
70-79			0.22	0.22	0.45	2.24	3.36	2.69	2.02	0.45	0.22			11.88
80-89				0.67	0.90	0.67	0.22	0.22	0.67	0.22	0.22			3.81
90-99		0.22			0.67	1.12	0.45	0.22						2.69
100-109						0.22								0.22
110-119						0.22	0.22							0.45
TOTAL %		1.12	0.67	3.59	9.87	13.90	21.52	19.28	16.59	7.40	3.81	1.35	0.67	N = 446

AGED 60–69

LDL-C (mg/dl)

HDL-C (mg/dl)	10-29	30-49	50-69	70-89	90-109	110-129	130-149	150-169	170-189	190-209	210-229	230-249	250-269	TOTAL %
10-19														
20-29				0.39	0.39	0.39		0.39						1.56
30-39				0.39	2.34	2.34	2.34	1.17	1.17	1.17	0.39	0.78		12.11
40-49				0.39	3.13	4.69	5.08	3.52	3.13	1.17	1.56	0.78		23.44
50-59				0.78	3.52	5.86	5.86	6.25	4.69	1.95	0.78	0.39		30.08
60-69				0.78	0.78	3.13	3.13	3.91	3.91	0.39	0.78	0.39	0.39	17.97
70-79				1.17	0.39	2.73	1.95	1.17	1.17	0.39	0.39			9.38
80-89				0.39	0.39	1.17	0.78		0.78					3.52
90-99				0.39			0.78							1.17
100-109								0.39						0.39
110-119														
TOTAL %				4.69	10.94	20.70	19.92	16.80	14.84	5.08	3.91	2.34	0.39	N = 256

AGED 70–79

Figure 2. Percentage distribution of HDL-C and LDL-C for females.

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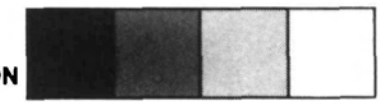

VLDL-C (mg/dl)

HDL-C (mg/dl)	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	TOTAL %
10-19		0.19						0.19					0.56
20-29	0.37	0.37	1.86	1.49	0.19	0.37	0.37	0.19	0.19	0.19			5.77
30-39	1.86	9.50	8.75	4.10	1.68	1.12	0.37						27.19
40-49	6.89	16.01	10.61	2.98	0.93								37.43
50-59	5.40	9.50	3.35	1.12	0.19								19.55
60-69	2.61	3.54	0.56	0.19									6.89
70-79	0.56	1.30		0.19									2.05
80-89	0.19	0.37											0.56
90-99													
100-109													
110-119													
TOTAL %	17.69	40.78	25.14	10.06	2.98	1.49	0.74	0.37	0.19	0.19			N = 537

AGED 20–29

VLDL-C (mg/dl)

HDL-C (mg/dl)	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	TOTAL %
10-19						0.13							0.26
20-29	0.26	1.41	1.41	1.79	1.28	0.51	0.51	0.26	0.51	0.13			8.18
30-39	2.56	7.03	8.82	5.88	2.05	1.79	1.28	0.26	0.13	0.13	0.13		30.31
40-49	4.35	13.68	9.97	3.45	1.66	0.51	0.13			0.13			33.89
50-59	3.58	7.67	4.22	1.92	0.64	0.26	0.26						18.54
60-69	2.17	1.92	1.28		0.26								5.63
70-79	1.41	0.77	0.26	0.13		0.13				0.13			2.81
80-89	0.13	0.26											0.38
90-99													
100-109													
110-119													
TOTAL %	14.45	32.74	25.96	13.17	6.01	3.20	2.17	0.51	0.64	0.51	0.13		N = 782

AGED 30–39

VLDL-C (mg/dl)

HDL-C (mg/dl)	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	TOTAL %
10-19				0.15									0.15
20-29	0.15	0.75	0.90	0.60	1.20	0.90	0.30	0.60		0.15	0.15		6.17
30-39	0.30	7.82	8.27	5.56	5.71	2.86	1.35	0.60	0.15	0.30		0.30	33.53
40-49	3.16	9.62	8.87	6.47	3.01	0.75	0.75	0.15		0.15	0.30		33.38
50-59	2.41	5.71	4.96	2.41	0.30	0.30	0.30		0.15				16.54
60-69	1.95	2.86	1.20	0.30	0.15		0.15				0.15		6.47
70-79	1.20	0.90		0.45									2.56
80-89		0.60				0.15							0.75
90-99		0.15											0.15
100-109													
110-119		0.30											0.30
TOTAL %	8.87	28.72	24.21	15.79	10.38	5.11	2.86	1.35	0.30	0.60	0.60	0.30	N = 665

AGED 40–49

VLDL-C (mg/dl)

HDL-C (mg/dl)	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	TOTAL %
10-19											0.30		0.30
20-29			1.20	1.20	2.11	0.90	0.30	0.30			0.30		6.63
30-39	1.51	2.41	5.12	7.53	3.92	3.61	0.30		0.30				25.30
40-49	2.11	6.93	10.24	7.53	2.71	2.11	0.60	0.30					32.53
50-59	3.01	7.83	6.02	3.31	2.41	0.60		0.30					23.49
60-69	0.30	0.90	3.31	1.20			0.30						6.02
70-79	0.90	0.60	1.20	0.30									3.01
80-89			0.30	0.30		0.30							0.90
90-99	0.30	0.60		0.30									1.20
100-109	0.30												0.30
110-119													
TOTAL %	8.43	19.28	27.71	21.69	11.14	7.53	1.51	0.90	0.30		0.60		N = 332

AGED 50–59

VLDL-C (mg/dl)

HDL-C (mg/dl)	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	TOTAL %
10-19													
20-29	0.51	0.51	2.04	1.02			0.51						5.10
30-39	0.51	6.12	7.14	5.61	5.61	1.53	1.02	1.02				0.51	29.59
40-49	3.06	6.12	13.78	4.08	2.55			1.02					31.12
50-59	3.06	4.08	8.67	2.55	3.06								21.43
60-69	2.04	2.55	2.04		0.51								7.14
70-79			1.02										1.02
80-89		1.02	1.02	1.02									3.06
90-99		0.51											0.51
100-109		0.51	0.51										1.02
110-119													
TOTAL %	9.18	21.43	36.22	14.29	11.73	1.53	1.53	2.04				0.51	N = 196

AGED 60–69

AGED 70–79

Figure 3. Percentage distribution of HDL-C and VLDL-C for males.

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AGED 20–29

HDL-C (mg/dl)	VLDL-C (mg/dl) 0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	TOTAL %
10-19													
20-29	0.41	0.21	0.62		0.21								1.45
30-39	1.24	4.15	2.07	1.04		0.21							8.71
40-49	6.85	12.66	5.60	0.41									25.52
50-59	11.62	15.56	3.94	0.41		0.21							31.74
60-69	8.51	8.09	1.66	0.41	0.41								19.09
70-79	4.36	4.36	0.62										9.34
80-89	1.24	1.45	0.62	0.21									3.53
90-99	0.21	0.41											0.62
100-109													
110-119													
TOTAL %	34.44	46.89	15.15	2.49	0.62	0.41							N = 482

AGED 30–39

HDL-C (mg/dl)	VLDL-C (mg/dl) 0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	TOTAL %
10-19							0.15						0.15
20-29	0.15	0.75	0.45	0.15	0.15								1.64
30-39	0.75	3.29	2.24	0.75	0.60	0.15							7.77
40-49	4.78	10.61	5.23	1.35	0.45								22.42
50-59	9.12	14.95	4.33	0.75	0.15	0.15						0.15	29.60
60-69	8.52	12.41	1.79	0.45	0.15	0.15							23.47
70-79	3.14	5.38	1.05	0.15									9.72
80-89	1.35	1.94	0.45										3.74
90-99	0.45	0.75											1.20
100-109	0.15	0.15											0.30
110-119													
TOTAL %	28.40	50.22	15.55	3.59	1.49	0.45	0.15					0.15	N = 669

AGED 40–49

HDL-C (mg/dl)	VLDL-C (mg/dl) 0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	TOTAL %
10-19													
20-29	0.16	0.33	0.16		0.16	0.16		0.16					1.15
30-39	0.49	2.30	3.61	0.99	1.19		0.33	0.16	0.16				9.18
40-49	2.30	10.66	5.74	2.30	0.82	0.33	0.49						22.79
50-59	4.59	13.28	9.02	1.64	0.33		0.16						29.18
60-69	5.74	8.85	2.46	0.49	0.33								17.87
70-79	4.26	5.57	0.82	0.16	0.16								10.98
80-89	2.13	2.46	0.66	0.16									5.41
90-99	1.15	0.82	0.33										2.30
100-109		0.33	0.16										0.49
110-119	0.33	0.16	0.16										0.66
TOTAL %	21.15	44.75	23.11	5.74	2.95	0.49	0.98	0.33	0.16				N = 610

AGED 50–59

HDL-C (mg/dl)	VLDL-C (mg/dl) 0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	TOTAL %
10-19													
20-29			0.16		0.16	0.16	0.16	0.33	0.16	0.16			1.48
30-39	0.16	0.82	0.66	3.61	0.82	0.16	0.66	0.33	0.16	0.16	0.33		8.21
40-49	0.82	3.94	5.91	5.25	2.96	1.31	0.16		0.16		0.16		20.69
50-59	2.79	8.70	6.57	2.96	2.30	0.99	0.82			0.33			25.45
60-69	5.09	6.08	5.09	3.45	0.33	0.33				0.16			20.53
70-79	2.63	4.76	3.28	1.15	0.33	0.16	0.16			0.33			12.81
80-89	1.64	2.79	0.66	1.64	0.33	0.16	0.16				0.16		7.55
90-99	0.16	0.66	0.99										1.81
100-109	0.16	0.16	0.33										0.66
110-119	0.33	0.33											0.66
TOTAL %	13.79	28.24	23.81	18.06	7.22	3.28	2.13	0.66	0.49	1.15	0.66		N = 609

AGED 60–69

HDL-C (mg/dl)	VLDL-C (mg/dl) 0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	TOTAL %
10-19													
20-29	0.22	0.45	0.45		0.22		0.22						1.57
30-39		1.12	2.02	1.35	0.90	1.12	0.22	0.67	0.22	0.22			7.85
40-49	1.12	3.59	7.17	4.48	3.36	1.57	0.90	0.22	0.22	0.22	0.22	0.22	23.32
50-59	2.02	7.85	9.42	5.38	3.14	1.57			0.67	0.45			30.72
60-69	2.69	5.83	4.48	2.91	0.90	0.22							17.04
70-79	1.57	3.81	3.36	2.69	0.22		0.22						11.88
80-89	0.22	1.35	1.35	0.90									3.81
90-99	0.67	1.12	0.45	0.22	0.22								2.69
100-109			0.22										0.22
110-119		0.22		0.22									0.45
TOTAL %	8.52	25.56	28.92	18.39	8.97	4.48	1.57	0.90	1.12	0.90	0.22	0.22	N = 446

AGED 70–79

HDL-C (mg/dl)	VLDL-C (mg/dl) 0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	TOTAL %
10-19													
20-29	0.39										0.78		1.56
30-39	0.39	1.56	0.78	3.13	3.62	0.78	1.17		0.39			0.39	12.11
40-49	0.39	3.52	5.47	5.86	4.69	1.17	0.78	1.17			0.39		23.44
50-59	3.52	4.30	7.81	8.20	2.73	3.13				0.39			30.08
60-69	1.17	4.30	6.25	3.91	0.78	1.17		0.39					17.97
70-79	0.78	3.13	3.13	1.56	0.78								9.38
80-89	0.78	1.17	1.17	0.39									3.52
90-99	0.39	0.78											1.17
100-109													
110-119	0.39												0.39
TOTAL %	8.59	18.75	24.61	23.05	12.50	6.25	1.95	1.56	0.39	0.39	1.17	0.39	N = 256

Figure 4. Percentage distribution of HDL-C and VLDL-C for females.

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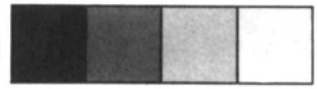

50 75 95 100

VLDL-C (mg/dl)

LDL-C (mg/dl)	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	TOTAL %
10-29									0.13	0.13			0.26
30-49	0.13	0.26							0.13				0.51
50-69	0.77	1.28	0.38	0.26		0.26	0.13			0.13			3.32
70-89	3.45	4.35	2.56	0.64	0.51	0.26		0.13					12.15
90-109	3.07	7.42	4.35	2.17	1.41	0.64	1.02	0.13		0.13	0.13		20.46
110-129	3.84	9.72	8.39	2.56	1.28	0.77	0.38	0.13	0.26				25.32
130-149	1.53	5.75	5.50	4.22	1.66	0.64	0.51	0.13					19.95
150-169	0.77	2.17	3.58	1.79	0.51	0.51							9.46
170-189	0.64	1.15	2.05	1.15	0.26	0.13	0.13			0.13			5.63
190-209	0.26	0.38	0.64	0.26	0.13								1.66
210-229		0.26	0.38	0.13	0.26				0.13				1.15
230-249													
250-269													
TOTAL %	14.45	32.74	25.96	13.17	6.01	3.20	2.17	0.51	0.64	0.51	0.13		N = 782

AGED 20–29

VLDL-C (mg/dl)

LDL-C (mg/dl)	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	TOTAL %
10-29													
30-49		0.15											0.30
50-69	0.45	0.45		0.30		0.15				0.15	0.15		1.65
70-89	1.35	3.01	1.50	0.75	0.60	0.75	0.15		0.30		0.15	0.15	8.87
90-109	1.80	4.21	3.46	2.11	1.20	0.30	0.30	0.30		0.15	0.15		14.14
110-129	1.65	6.77	6.47	3.46	2.71	1.06	0.75	0.15		0.15	0.15	0.15	23.76
130-149	1.35	7.82	6.92	4.36	2.26	1.65	0.75	0.90					25.86
150-169	1.50	3.91	3.31	1.80	1.65	0.45	0.15	0.30		0.15			13.23
170-189	0.30	1.05	1.80	2.56	1.20	0.60	0.30						7.82
190-209	0.30	0.75	0.45	0.30	0.15	0.15	0.30						2.41
210-229		0.30	0.30	0.15	0.45								1.20
230-249		0.30					0.15						0.45
250-269					0.15								0.15
TOTAL %	8.87	28.72	24.21	15.79	10.38	5.11	2.86	1.35	0.30	0.60	0.60	0.30	N = 665

AGED 40–49

VLDL-C (mg/dl)

LDL-C (mg/dl)	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	TOTAL %
10-29													
30-49													
50-69		0.30	0.60	0.60	0.30		0.30	0.30			0.30		3.31
70-89	0.60	1.51	3.01	1.20	0.60	0.30			0.30				7.53
90-109	1.51	2.71	5.72	1.81	1.81	0.30	0.30				0.30		14.76
110-129	1.81	5.12	7.23	5.42	1.81	2.11	0.30						23.80
130-149	2.41	4.82	4.82	3.92	3.01	2.71		0.30					21.99
150-169	0.60	3.01	3.01	3.61	1.51	0.90							12.65
170-189	1.51	0.90	1.51	2.41	1.20	0.60		0.30					8.43
190-209		0.90	1.20	2.11	0.90	0.30	0.30						5.72
210-229			0.60	0.60		0.30	0.30						1.81
230-249													
250-269													
TOTAL %	8.43	19.28	27.71	21.69	11.14	7.53	1.51	0.90	0.30		0.60		N = 332

AGED 60–69

VLDL-C (mg/dl)

LDL-C (mg/dl)	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	TOTAL %
10-29													
30-49	0.19	0.93	0.19										1.30
50-69	1.86	3.17	1.12	0.19	0.19								6.52
70-89	4.84	9.68	2.42	1.30	0.19		0.19			0.19			18.99
90-109	4.29	11.92	7.26	2.05	0.74	0.66		0.19	0.19				27.37
110-129	3.91	8.19	6.52	2.23	0.56	0.74	0.19	0.19					22.53
130-149	2.23	5.21	4.84	3.17	0.74	0.19							16.39
150-169	0.37	1.12	1.49	0.93	0.56		0.19						4.66
170-189		0.37	1.12				0.19						1.68
190-209		0.19	0.19										0.37
210-229													
230-249													
250-269													
TOTAL %	17.69	40.78	25.14	10.06	2.98	1.49	0.74	0.37	0.19	0.19			N = 537

AGED 30–39

VLDL-C (mg/dl)

LDL-C (mg/dl)	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	TOTAL %
10-29									0.21	0.21			0.62
30-49				0.21									0.42
50-69	0.62	0.21	0.83		0.82			0.21				0.21	2.91
70-89	0.42	2.48	2.70	0.62	0.82	0.42	0.42	0.21	0.42	0.21	0.42	0.21	9.15
90-109	0.42	3.33	3.74	1.66	1.46	0.21	0.83	0.42	0.21	0.42	0.21	0.21	13.10
110-129	1.87	4.57	6.03	2.91	1.87	0.83	0.21	0.83	0.42		0.21		19.75
130-149	2.29	5.41	4.99	3.95	3.12	1.66			0.82		0.21		22.25
150-169	2.08	2.70	3.53	4.16	1.66	0.21	0.42	0.21					14.97
170-189	0.42	2.29	1.46	2.29	1.04	0.21	0.42	0.42	0.21	0.21			8.94
190-209	0.21	0.82	1.66	0.83		1.46							4.78
210-229		0.62	0.42	0.42	0.62								2.08
230-249	0.21			0.21									0.42
250-269				0.21									0.21
TOTAL %	8.32	22.45	25.36	17.46	11.23	4.99	2.29	2.29	2.08	1.04	1.04	0.62	N = 481

AGED 50–59

VLDL-C (mg/dl)

LDL-C (mg/dl)	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	TOTAL %
10-29													
30-49				0.51				0.51					1.53
50-69	0.51	0.51	1.02										2.04
70-89	1.02	5.10	4.08	1.53	0.51								12.76
90-109	0.51	4.08	5.10	0.51	1.02		0.51	0.51					12.24
110-129	2.04	6.63	9.69	3.57	4.08	0.51		0.51					27.04
130-149	3.06	2.04	7.65	2.04	3.57	0.51	0.51	0.51				0.51	20.41
150-169	1.02	3.06	4.59	2.55	0.51	0.51	0.51						13.27
170-189	0.51		2.55	2.04	1.02								6.12
190-209	0.51		0.51	1.53	0.51								3.06
210-229			0.51										0.51
230-249					0.51								0.51
250-269			0.51										0.51
TOTAL %	9.18	21.43	36.22	14.29	11.73	1.53	1.53	2.04				0.51	N = 196

AGED 70–79

Figure 5. Percentage distribution of LDL-C and VLDL-C for males.

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AGED 20–29

LDL-C (mg/dl) \ VLDL-C (mg/dl)	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	TOTAL %
10-29													
30-49	0.62	1.24	0.21										2.07
50-69	0.21	0.83	1.24	0.21		0.21							12.03
70-89	11.00	13.48	2.27	0.21									28.42
90-109	18.17	15.15	4.56	0.41									30.29
110-129	4.56	6.22	2.27	1.04	0.21	0.21							15.56
130-149	2.48	2.90	1.04	0.21									6.64
150-169	0.83	0.41	0.41	0.41	0.21								2.28
170-189	0.62	0.21	0.62										1.45
190-209	0.41	0.41	3.21		0.21								1.24
210-229													
230-249													
250-269													
TOTAL %	34.44	46.89	15.15	2.49	0.62	0.41							N = 482

AGED 30–39

LDL-C (mg/dl) \ VLDL-C (mg/dl)	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	TOTAL %
10-29		0.15										0.15	0.30
30-49	0.90	0.60	0.15										1.64
50-69	2.84	4.78	0.75	0.45		0.15							8.97
70-89	8.67	12.71	3.44	0.60	0.30								25.71
90-109	8.37	15.84	2.84	0.30	0.45								27.80
110-129	3.89	10.46	3.44	0.75			0.15						18.68
130-149	2.39	3.29	2.69	0.45		0.30							9.12
150-169	1.05	1.35	1.64	0.80	0.45								5.08
170-189	0.15	0.45	0.90	0.45	0.15								1.79
190-209		0.30											0.30
210-229		0.15											0.15
230-249		0.15			0.15								0.30
250-269	0.15												0.15
TOTAL %	28.40	50.22	15.55	3.59	1.49	0.45	0.15					0.15	N = 669

AGED 40–49

LDL-C (mg/dl) \ VLDL-C (mg/dl)	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	TOTAL %
10-29										0.16	0.16		0.33
30-49						0.16							0.16
50-69	0.33	0.16		0.33			0.16						0.99
70-89	0.66	1.81	1.81	0.66	0.16	0.33	0.16		0.16				5.75
90-109	2.48	3.78	1.48	2.48	0.33	0.33			0.16	0.16	0.16		11.33
110-129	3.12	7.72	5.58	4.11	0.66	0.66	0.66	0.33		0.33	0.33		23.81
130-149	2.96	4.43	6.08	4.93	2.46	0.49	0.16	0.16					21.67
150-169	1.97	4.27	4.27	2.48	1.31	0.49	0.49			0.16			15.60
170-189	1.15	3.45	2.96	1.64	0.82	0.49		0.16		0.16			10.84
190-209	0.99	1.48	0.49	0.82	0.99	0.16	0.16						5.09
210-229		0.82	0.66	0.49	0.33	0.16	0.16						2.63
230-249	0.16	0.33	0.16				0.16			0.16			0.99
250-269									0.16				0.16
TOTAL %	13.79	28.24	23.81	18.06	7.22	3.28	2.13	0.66	0.49	1.15	0.66		N = 609

AGED 50–59

LDL-C (mg/dl) \ VLDL-C (mg/dl)	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	TOTAL %
10-29													
30-49													
50-69													
70-89	1.17	0.78	0.78	0.39	0.39			0.39	0.39		0.39		4.69
90-109	1.17	3.52	2.73	1.95	0.39	0.39						0.39	10.94
110-129	0.78	4.69	4.69	6.25	2.73		0.39	0.39		0.39	0.39		20.70
130-149	3.13	4.30	3.91	3.52	2.34	1.56	0.78	0.39					19.92
150-169	1.17	1.95	3.91	4.30	2.34	1.95	0.39	0.39			0.39		16.80
170-189	0.78	1.56	5.08	4.30	1.56	1.56							14.84
190-209		1.17	1.56	0.39	0.78	0.78	0.39						5.08
210-229		0.39	1.56	0.78	1.17								3.91
230-249	0.39			1.17	0.78								2.34
250-269			0.39										0.39
TOTAL %	8.59	18.75	24.61	23.05	12.50	6.25	1.95	1.56	0.39	0.39	1.17	0.39	N = 256

AGED 60–69

LDL-C (mg/dl) \ VLDL-C (mg/dl)	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99	100-109	110-119	TOTAL %
10-29													
30-49			0.22	0.67		0.22							1.12
50-69	0.22			0.22		0.22							0.67
70-89	0.45	0.90	0.45	0.90	0.45				0.22	0.22			3.59
90-109	0.67	2.91	3.14	1.12	1.12	0.22			0.22	0.22		0.22	9.87
110-129	1.79	4.26	3.59	2.69	0.45	0.22	0.45	0.22					13.90
130-149	1.57	6.73	6.73	2.69	1.79	0.90	0.67	0.22	0.22				21.52
150-169	1.57	4.48	6.29	3.81	2.02	0.22		0.45		0.22	0.22		19.28
170-189	1.12	3.81	4.48	3.81	1.79	1.12	0.22		0.22				16.59
190-209	0.90	1.57	2.47	0.67	0.90	0.67				0.22			7.40
210-229	0.22	0.67	1.12	0.90	0.45	0.22			0.22				3.81
230-249		0.22	0.22	0.45		0.22	0.22						1.35
250-269			0.22	0.22		0.22							0.67
TOTAL %	8.52	25.56	28.92	18.39	8.97	4.48	1.57	0.90	1.12	0.90	0.22	0.22	N = 446

AGED 70–79

Figure 6. Percentage distribution of LDL-C and VLDL-C for females.

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maining medium light and lightest shades of gray encompasses 95% and 100% of the sample, respectively. To avoid an arbitrary separation by shaded areas, cells representing equal percentages are grouped into one shade of gray so that cumulative percentages approximate those given by the key as closely as possible.

Consistent with the observations made from Tables 1 to 3 are the changes in the bivariate distributions of lipoprotein cholesterols for the age and gender group in Figures 1 to 6. According to Tables 1 to 3, there were no changes in average HDL-C with age, but LDL-C and VLDL-C were higher in the older age groups. However, all three lipoprotein density classes, including HDL-C, exhibited increased variation with increasing age. The trends in variance were statistically significant in every case for both men and women. Changes in the means and variances of LDL-C and VLDL-C are reflected by the drifting of the observed percentages of lipoprotein cholesterol combinations from the upper left to the lower right in the panels of Figures 5 and 6 as both lipoprotein cholesterols increase with age.

Median levels of HDL-C among males were always lower than median levels of HDL-C for females (Table 1). Median levels of LDL-C among males exceeded those for nonusers of hormones aged 15 through 54 (Table 2). These comparisons between sexes are reflected in the bivariate relationships between HDL-C and LDL-C observed in Figures 1 and 2. The percentages of lipoprotein cholesterol combinations among females are slightly to the left (perhaps less apparent for those aged 60 to 79 years) and were lower than those observed among males.

As with LDL-C, median levels of VLDL-C among males were usually higher than for female nonusers of hormones (Table 3). The exception occurred for those aged 70 to 79. As a result, a similar pattern of comparison as between HDL-C and LDL-C in Figures 1 and 2 was observed for the bivariate percentage distribution of HDL-C and VLDL-C combinations found in Figures 3 and 4.

The observed bivariate distributions between the lipoprotein cholesterols for males were usually lower and to the right when compared to females (Figures 5 and 6), reflecting higher levels of LDL-C and VLDL-C among males. For those aged 60 to 79 years, females appeared to be more variable in levels of lipoprotein cholesterols, making males and females more similar.

Discussion

Efforts to determine the factors that influence lipoprotein cholesterol levels continue to uncover relationships of considerable strength.[8–11] It is evident that the distribution of habits, life styles, and hereditary characteristics of a particular sample may affect the findings of a descriptive analysis. The problems of methodological differences and technical errors must also be kept in mind. While biases specific to lipoprotein determinations of the Framingham lipoprotein laboratory cannot be ruled out as a cause of any interstudy differences, participation in rigorous internal and external measurement standardization programs makes such an explanation unlikely.

In general, the differences between univariate distributions presented in Tables 1 to 3 and those published by the LRC program[4] are modest. For example, the largest mean difference in HDL-C among men between the ages of 25 and 55 is 1.5 mg/dl for the 30 through 34 year-old age group. The Framingham median HDL-C levels usually fall between the 25th and 50th percentiles of HDL-C given by the LRC. The exception occurs among females aged 20 to 24 and 30 to 39 years who are not receiving estrogen hormone preparations, where median levels of HDL-C among the Framingham participants are between the 50th and 75th LRC percentiles.

Differences in the reported levels of LDL-C reflect a less consistent pattern of comparison. Among males aged 20–54 years, median levels of LDL-C in Framingham fall between the 50th and the 75th percentiles of the LDL-C levels reported by the LRC. For the other male age groups, Framingham median LDL-C levels are between the 25th and the 50th percentile LRC range. All female groups, except those 35 to 39 years, have median levels of LDL-C between the 50th and the 75th percentiles of the LRC data. For those 35 to 39 years old and not receiving hormone therapy, the median level of LDL-C falls between the 25th and the 50th percentiles. This finding also occurs among females aged 25 to 29 years who reported using hormones.

Median levels of Framingham VLDL-C always exceeded median levels reported by the LRC. For both sexes in the 15 to 59-year-old age group, median levels of VLDL-C were between the 50th and the 75th percentiles of the LRC data. For men and women ages 60 to 79 years, the median levels of VLDL-C for the Framingham Study participants fell between the 75th and the 90th percentiles reported by the LRC. This discrepancy, however, occurs in age groups where the Framingham sample size is about 50% larger than the LRC sample. This finding is also paralleled by a tendency toward lower HDL-C levels in both Framingham men and women in this age range. As both lipoprotein cholesterols may be potential CHD risk factors in this age group,[12] the cited differences may be of considerable consequence, particularly if interstudy projections of risk are attempted.

Summarizing the differences between the Framingham and LRC data, we find that HDL-C and LDL-C levels are very similar and VLDL-C levels slightly higher in the Framingham Study. The most conspicuous differences occur for VLDL-C in both men and women aged 60 years or older. It is possible that differences in methodology, despite all efforts at standardization, caused these minor differences, but life-style differences between the two populations would appear to be a more likely explanation.

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The regulation of lipoprotein metabolism is very complicated, with a large number of tissues and major organ systems involved.[13] While the detailed description of lipoprotein particle structure or content is not presently possible in any epidemiologic setting, a multidimensional presentation of lipoprotein cholesterol levels for the broad lipoprotein density classes is of interest. Such a step might lead to recognition of major sources of variation in the lipoprotein content of individuals. Questions that can be asked of the displays in Figures 1 to 6 include: Are there distinct subgroups in this sample? How do these subgroups differ by age and gender? What are the consequences for subjects in these subgroups? The latter question will be addressed in a subsequent report.

Figure 1 presents the bivariate distribution of the two lipoprotein cholesterol measurements that have been most closely associated with the development of coronary heart disease among men, LDL-C and HDL-C.[14, 15] Notice that a transition from a nearly circular-appearing joint distribution at ages 20 to 29 years tends to shift and distort with age and then, at ages 70 to 79 reverts to a pattern similar to the 20 to 29-year-old group.

There are at least two major forces that may influence these cross-sectional shifts with age in the joint distributions. First, in the younger one-half of the age spectrum presented here, the lipoprotein cholesterol levels may actualy change with age. These alterations may stem from changes in the properties of the sample, and not from age itself. Second, and potentially important in the second one-half of the age spectrum, is the influence of mortality (or selective survival). In this case the sample structure is altered because only survivors are measured.

A shift with age of lipoprotein cholesterol distributions to "high risk"[14–17] combinations of HDL-C and LDL-C is clearly evident when the first four panels of Figure 1 are compared. An example of how this describes a group of highly susceptible subjects can be seen by comparing the proportion of the sample aged 20 to 29 with HDL-C < 40 and LDL-C > 150 (2.24%) with those men aged 40 to 49 (10.52%). Comparison with Table 4 shows that the approximate 95th cumulative percentile of HDL-C and LDL-C combinations among males aged 20 to 29, which excludes percentages indicated by the lightest shade of gray in Figure 1, is represented by only about 80% of the men aged 50 to 59 years. For those aged 70 to 79, the pattern of lipoprotein combinations tends to resemble that of those aged 20 to 29 years. This finding suggests selective survival of a low LDL-C and high HDL-C subgroup among the oldest members of the Framingham sample.

The migration of the pattern for women in the panels of Figure 2 seems to be even more pronounced, as the HDL-C values disperse and the LDL-C values rise with increasing age. A comparison with Table 4 illustrates that the approximate 95th cumulative percentile of HDL-C and LDL-C combinations among those aged 20 to 29 is poorly represented among the older women (less than 60%). As would be expected if selective survival had less influence in women, the panels for the oldest ages would not tend to revert to the patterns of the young adult.

Table 4. Percentage of Subjects in the Approximate Cumulative 95th Percentile of Lipoprotein Cholesterol Combinations for Persons Ages 20 to 29

Age (yrs)	HDL-C and LDL-C	HDL-C and VLDL-C	LDL-C and VLDL-C
Males			
20–29	95.88	95.88	96.22
30–39	89.35	89.84	86.61
40–49	85.59	87.40	79.14
50–59	81.04	79.78	71.02
60–69	82.26	83.47	77.16
70–79	83.68	85.72	84.70
Females			
20–29	92.57	94.42	95.23
30–39	88.31	90.55	90.41
40–49	79.41	84.78	81.37
50–59	62.67	62.78	53.78
60–69	50.96	56.36	43.85
70–79	59.39	49.23	45.75

Figures 3 and 4 indicate how the inverse relationship between HDL-C and VLDL-C varies with age and gender; the strongest associations appear in middle-aged men and older women. Table 4 shows that the aproximate 95th cumulative percentile of HDL-C and VLDL-C combinations in the youngest age group is less represented among older males (85%) and far less represented among the oldest females (less than 50%).

In Tables 2 and 3, LDL-C and VLDL-C individually show the largest increases with age. These changes are also apparent with age in Figures 5 and 6. This is illustrated among men by the migration of patterns in Figure 5 toward the lower right hand corner as age decades increase. Table 4 summarizes this observation, as the approximate 95th cumulative percentile of lipid combinations among the youngest males is less represented in the older groups of males (85% or less). Among males aged 50 to 59, these combinations include only 70% of the sample. This result and Figure 5 suggests there exists a subgroup of middle-aged males with elevated VLDL-C and below average LDL-C who may not survive (or be free of CHD) to have their lipid characteristics appear among those represented in the oldest group of males. Most of this subgroup aged 50 to 59, in which low HDL-C levels are also very common, would clearly meet the criteria for Fredrickson Type IV hyperlipoproteinemia.[3] A subgroup analogous to Type IIA (hyperbetalipoproteinemia) is much less conspicuous, except perhaps at age 30 to 39.

In women, the VLDL-C increase occurs later in life (see also Table 3), and there apears to be a more gradual and homogeneous shift toward the lower right-hand corner of the panels of Figure 6. Table 4

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describes the rate of this shift in terms of the percentage of LDL-C and VLDL-C combinations in the older age groups that fall into the approximate 95th cumulative percentile of lipoprotein cholesterol combinations among the youngest females. Among the oldest females, about 45% fall into the 95th cumulative percentile of lipid combinations in the youngest female age group.

One additional property of these data that should be mentioned is the tendency for the variance of HDL-C to increase with age, while the mean changes very little. In men the increase in variance coincides with the age at which the rates of occurrence of clinically recognizable coronary heart disease increases rapidly (about age 50).

It is clear from even the most cursory inspection of Figures 1 to 6 that there are striking differences in lipoprotein profiles of this sample for the ages presented. It is doubtful that such large differences are the natural consequence of aging. For this reason, the bivariate distributions shown for 20- to 29-year olds might be taken as guidelines for optimal cardiovascular health. Additional reports in this series will explore and identify factors which explain a portion of these differences but, as other authors have suggested,[18] the homogeneity of this typical American sample for high fat and caloric intake, along with low physical activity and obesity, often reduces the statistical power of such analyses. Under such circumstances, the explanation of major sources of the variance of lipoprotein cholesterol levels must be left to other study designs.

A tabulation of the joint distributions of the three pairs of lipoprotein cholesterol measurements is presented to show properties (such as shape and scatter) which cannot be appreciated by using summary measures such as correlation coefficients. A previous report[19] has indicated the importance of considering the joint relationships between lipoprotein cholesterols and the influence these relationships have on CHD. It is believed that relationships among lipoprotein cholesterols should be considered when evaluating the association between lipoprotein cholesterols and CHD because certain combinations of lipoprotein cholesterols may be uncommon or more likely to be associated with CHD than others. For example, low levels of HDL-C and elevated levels of both LDL-C and VLDL-C may be an especially unhealthy combination of lipoprotein cholesterols. The result may imply that an important association between a lipoprotein cholesterol exists through relationships with other lipoprotein cholesterols even though an independent association with CHD cannot be demonstrated. The last of this series of papers will explore the importance of this latter issue and also provide traditional methods of assessment of the association between lipoprotein cholesterols and CHD.

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Index Terms: blood lipids • distribution • coronary heart disease • high density lipoprotein cholesterol • low density lipoprotein cholesterol • very low density lipoprotein cholesterol

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