Prevalence of Elevated Serum Cholesterol in Personnel of the U.S. Navy

LINDA KELLY TRENT, MA

Ms. Trent is a Research Psychologist with the Health Services Research Department, Naval Health Research Center, San Diego CA. HM2 James Bethea, a Hospital Corpsman formerly with the Naval Health Research Center, assisted in collecting the data.

This research was supported in part by the Naval Military Personnel Command (work order No. N0002289WRWW542) and by the Naval Medical Research and Development Command (work unit No. 63706N.M0095.005), Department of the Navy. The views in this paper do not reflect the official policy or position of the Department of the Navy or the Department of Defense.

Tearsheet requests to Ms. Linda Kelly Trent, MA, Health Services Research Department, Naval Health Research Center, P.O. Box 85122, San Diego, CA 92186-5122.

Synopsis

Fasting blood lipid profiles were collected for 5,487 active duty Navy men and women presenting for routine physical examinations. Mean serum cholesterol for the sample (mean age 33.6 years) was 208.2 milligrams per deciliter (mg per dL). Cholesterol level increased with age, decreased with education, and was higher in men than in women. Using the Navy's own risk cutpoints for total cholesterol (200 mg per dL for ages 18–24, 220 mg per dL for ages 25 and older), 36.9 percent of the sample were found to be at risk.

When the percentage of the population at risk was computed using the guidelines suggested by the National Institutes of Health Consensus Conference, rather than the Navy's cutpoints, results were almost identical (36.3 percent at risk); when based on the National Cholesterol Education Program's recommended cutpoints, the percent at risk was considerably higher (55.4 percent). Risk estimates that included LDL- or HDL-cholesterol risk levels (or both) also were higher.

A larger percentage of Navy personnel were at risk because of total cholesterol than were persons in an age-adjusted national sample. However, because routine examinations generally are not given until first reenlistment, the Navy sample underrepresented younger service members, and results may overestimate the prevalence of hypercholesterolemia in the Navy at large.

The author draws attention to the problem of lack of standardization in cholesterol testing and notes that the Navy does not yet participate in an external quality control program. The difficulty in setting appropriate risk cutpoints, given the complexity of factors that must be considered as well as the general unreliability of cholesterol tests, is also discussed.

CARDIOVASCULAR DISEASE is the leading cause of death in the United States, accounting for almost half of the nation's mortality and costing nearly $90 billion annually (*1*). Both humanitarian and financial concerns contribute to the growing interest in identifying persons at risk for developing premature cardiovascular disease, especially if that risk can be modified downward. Epidemiologic studies, most notably the Lipid Research Clinics Coronary Primary Prevention Trial, provide strong evidence for a causal link between increased blood cholesterol levels and increased risk of coronary heart disease (*2–7*). In the wake of such studies, cholesterol screening programs and nutrition education campaigns have appeared in private and public sectors alike.

In December 1984, the National Institutes of Health (NIH) Consensus Development Conference on Lowering Blood Cholesterol (*8*) chose to define moderate and high risk levels of blood cholesterol that were adjusted for age (table 1). Using these NIH values, the second National Health and Nutrition Examination Survey (NHANES II) (*9*) results showed that approximately 35 percent of civilian adults nationwide exceeded desirable cholesterol levels and were at risk for premature coronary heart disease (CHD).

More recently, an expert panel for the National Cholesterol Education Program (NCEP) (*10*) recommended uniform risk cutpoints for adults of all ages. According to these guidelines, all adults 20 years of age and older should maintain a serum cholesterol value below 200 milligrams per deciliter (mg per dL); borderline-high cholesterol level was

Table 1. Overview of various blood lipid risk cutpoint values

Lipid variable	Agency	Age group	Risk levels			
			Category	Definition	Category	Definition
Total cholesterol	NIH[1]	20–29	Moderate	201–220 mg per dL	High	> 220 mg per dL
	NIH[1]	30–39	Moderate	221–240 mg per dL	High	> 240 mg per dL
	NIH[1]	40 or older	Moderate	241–260 mg per dL	High	> 260 mg per dL
	NCEP[2]	20 or older	Borderline-high	200–239 mg per dL	High	240+ mg per dL
	Navy	18–24	At risk	> 200 mg per dL		
	Navy	25 or older	At risk	> 220 mg per dL		
LDL-cholesterol	NCEP[2]	20 or older	Borderline-high	130–159 mg per dL	High	160+ mg per dL
HDL-cholesterol	NCEP[2]	20 or older	At risk	< 35 mg per dL		
Triglycerides	NCEP[2]	20 or older	Moderate	250-500 mg per dL	High	> 500 mg per dL
Total cholesterol to HDL-cholesterol ratio	Navy	18 or older	At risk	> 5.0		

[1] National Institutes of Health, 1984.
[2] National Cholesterol Education Program, 1987.

NOTE: LDL = Low-density lipoprotein; HDL = high-density lipoprotein.

set at 200–239 mg per dL for all ages, and high cholesterol was defined as a value of 240 mg per dL or higher. In addition, because the causal relationship between cholesterol and heart disease now appears to rest largely with elevated levels of the low-density lipoprotein (LDL) fraction, the panel provided guidelines for borderline-high and high risk levels of LDL-cholesterol as well (table 1).

The NHANES II data show that more than 55 percent of the nation's civilian population have total cholesterol levels exceeding the NCEP panel's recommendation of 200 mg per dL, and if LDL-cholesterol levels were taken into account as well, the estimated prevalence of hypercholesterolemia would be even higher. Furthermore, it has been estimated that 36 percent of all adults ages 20–74 "are candidates for medical advice and intervention" because of high risk cholesterol levels or the combined risk factor load of elevated cholesterol plus other CHD risk factors (*11*).

Like a growing number of organizations, the U.S. Navy is seeking to reduce the incidence of cardiovascular disease among its members by identifying and treating persons with elevated cholesterol. The Navy recently promulgated its own standards for cholesterol risk levels (*12*), which are presented in table 1. These standards, like the NIH cutpoints, are age-adjusted, but the Navy's two age groups do not correspond with the three age groups delineated by the NIH. Note that the Navy makes no distinction between "moderate" or "borderline-high" and "high" risk levels; rather, a single cutpoint establishes the level at which persons within an age group are considered to be "at risk." Because of the discrepancies in standards represented in table 1, the term "elevated" is used generically throughout this paper to refer to lipid levels which pose an increased risk (great or slight) of heart disease. Thus, "elevated" cholesterol refers inclusively to moderate, borderline-high, and high risk levels of cholesterol.

Research is needed to establish baseline and longitudinal data bases for determining the prevalence of hypercholesterolemia among Navy personnel and selected subgroups, correlates (or predictors) of undesirable cholesterol levels, patterns of change, and efficacy of interventions. Blair and coworkers (*13*) have initiated this research effort, reporting that 48 percent of their Navy sample (1,000 active duty members, ages 20–50 and older) had cholesterol levels equal to or greater than 200 mg per dL. The purpose of my study was to (*a*) replicate those initial findings and extend them to a broader Navy sample; (*b*) compare risk rates using the new Navy standards with standards using the more traditional cutpoints; (*c*) estimate prevalence of risk on total cholesterol, LDL-cholesterol, HDL-cholesterol, triglycerides, and the total cholesterol to HDL-cholesterol ratio; (*d*) examine prevalence of risk among various subgroups; (*e*) compare Navy patterns with national norms; and (*f*) draw attention to some problems inherent in interpreting these data.

Methods

During a 3-month period from mid-April to mid-July 1989, blood lipids data were collected for all active duty personnel presenting for routine physical examinations in the catchment areas of two major naval hospitals. Data from inpatient admissions and outpatient visits for medical prob-

lems were not included in the sample. Laboratories at both hospitals (Lab 1 and Lab 2) employed an enzymatic procedure with blood serum to determine cholesterol concentrations. Lab 1 used a Technicon SMAC analyzer; Lab 2 used a Hitachi 736-30 analyzer. Internal quality control procedures were operative at both laboratories, but the Navy does not yet participate in an external quality control program to standardize blood cholesterol analysis among its medical centers.

Fasting blood lipid values in this study were obtained for total cholesterol (TOTCHOL), high-density lipoprotein (HDL) cholesterol, and triglycerides (TRIG); the LDL-cholesterol variable (LDL) was computed from these using the formula LDL = TOTCHOL − HDL − (TRIG ÷ 5) (*10*). Demographic information was obtained for participants by matching their Social Security numbers on the cholesterol records with those on the Navy's Master Enlisted Record and Master Officer Record, resulting in a final sample of 5,487 active duty men and women. Nonmatches (about 16 percent) were attributed to status other than Navy active duty (for example, Navy retired or Marine Corps active duty).

The sample was 93 percent men and 7 percent women. Mean age was 33.6 years (range = 18–61). Seventy-six percent of the sample were enlisted personnel, 24 percent were officers; 6 percent had less than a high school education, 58 percent had completed 12 years of schooling, and 36 percent had taken course work beyond a high school diploma. Racial composition of the sample was 78 percent white, 11 percent black, and 11 percent other.

Demographically, patients served by the two laboratories in the study were nearly identical; however, the total sample was somewhat older, better educated, and composed of a greater percentage of officers than the entire Navy. These differences were probably attributable to the fact that, with the exception of discharge examinations, routine physical examinations are usually not given until the person's first reenlistment. Examinations are also scheduled more frequently for those ages 50 or older, and there are proportionally more officers among older personnel than among younger service members.

The Navy's recommended risk cutpoints have been used in most of the analyses reported subsequently. The NIH Consensus Conference cutpoints have been used if comparisons with national norms (from NHANES II) were desired. The NHANES II sample of 11,864 persons with blood cholesterol data is representative of the noninstitutionalized civilian adult population of the United States between 1976 and 1980. The 63 persons in this Navy sample who were 18–19 years of age were excluded from normative comparisons with the national sample because the NHANES II norms begin with the 20-year-olds. The norms themselves, based on ages 20–74, were age-adjusted in these analyses to ages 20–54 (or 20–44 in some cases) so as not to bias comparisons with the younger Navy sample. The reader should also note that small cell sizes in certain Navy subgroups (for example, older women) sometimes required limiting analyses to adequately represented groups within the Navy sample itself.

Table 2. Mean blood lipid values (in mg per dL) by sex of Navy personnel and laboratory, 1989

Laboratory and sex	TOTCHOL	LDL	HDL	TRIG	TOTCHOL to HDL ratio	Number
Total...	208.2	131.8	49.0	131.9	4.5	5,487
Lab 1.....	212.8	133.8	50.8	134.2	4.3	1,977
Men.....	213.2	134.6	49.6	136.6	4.4	1,816
Women.....	208.2	123.9	65.1	106.5	3.2	161
Lab 2.....	205.7	131.5	48.7	130.8	4.5	3,510
Men.....	206.5	132.5	47.9	133.5	4.6	3,283
Women.....	194.3	117.5	59.3	90.9	3.4	227

NOTE: TOTCHOL = total cholesterol; LDL = low-density lipoprotein fraction; HDL = high-density lipoprotein fraction; TRIG = triglycerides.

Emphasis has been given to total cholesterol values and the overall percent of persons at risk due to elevated total cholesterol. However, the NCEP panel noted that elevated LDL-cholesterol (≥ 130 mg per dL) and low HDL-cholesterol (< 35 mg per dL) are also major independent risk factors that should be considered when evaluating a person's lipid profile (*10*). An elevated triglyceride level (> 250 mg per dL) (*10*) and a TOTCHOL to HDL ratio greater than 5.0 (*12*) are additional risk factors. All of these factors have been listed in table 1 and are included in some of the analyses that follow.

Results

Mean blood lipid values. Table 2 presents mean blood lipid values by sex for each hospital laboratory as well as for the sample as a whole (persons ages 18–61). Mean cholesterol level for the total sample was 208.2 mg per dL. Lab 1 values were significantly higher than those of Lab 2 for both TOTCHOL (212.8 mg per dL and 205.7 mg per dL, respectively, $P < 0.001$) and HDL (50.8 mg per dL versus 48.7 mg per dL, $P < 0.001$); it was

Figure 1. Mean total cholesterol values by age group and laboratory, U.S. Navy personnel, 1989

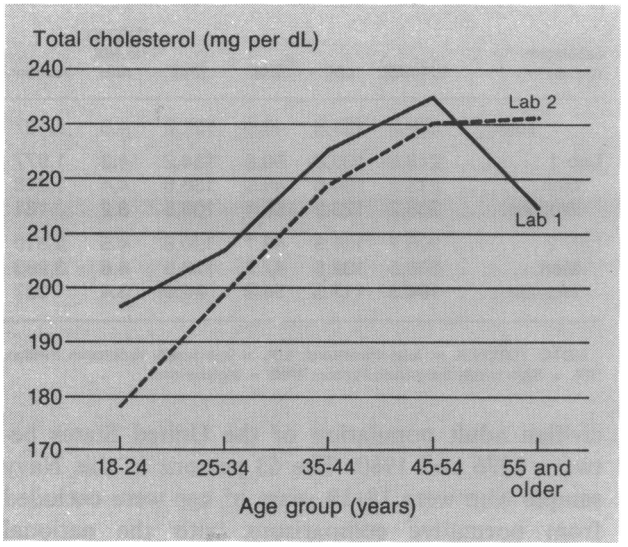
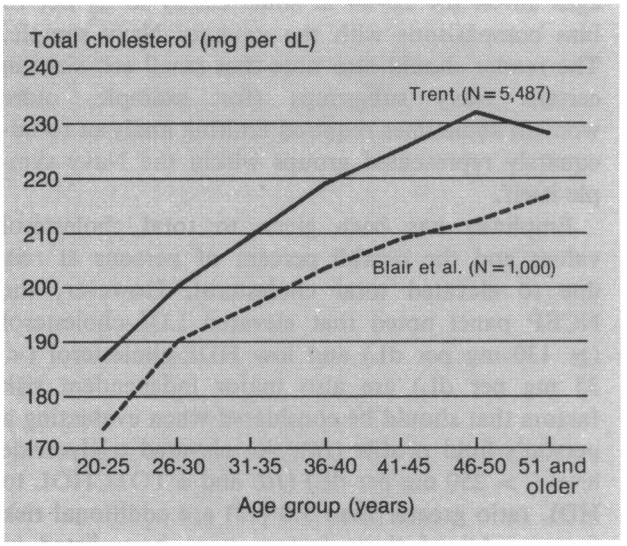


Figure 2. Comparison of mean total cholesterol values by age group in two samples of U.S. Navy personnel



also slightly higher on TRIG, but not significantly so. Serum samples of men tested at both laboratories demonstrated higher TOTCHOL values than did women's samples, yet there were proportionally fewer men tested at the higher-scoring Lab 1 (91.9 percent men) than at Lab 2 (93.5 percent). As shown in figure 1, mean cholesterol levels at both laboratories were higher at each succeeding age group until age 55, though the values for the oldest group (55 and older) are somewhat unreliable because of reduced cell sizes ($N=8$ for Lab 1, $N=18$ for Lab 2).

Sex differences in mean blood lipid values were explored further in a series of analyses of variance in which age was covaried. In these analyses, values for men were significantly higher than for women on LDL (132.8 mg per dL and 118.4 mg per dL, respectively, $P < 0.001$); TRIG (135.1 mg per dL versus 97.2 mg per dL, $P < 0.001$); the TOTCHOL to HDL ratio (4.5 versus 3.4, $P < 0.001$); but they were significantly lower on HDL (48.1 mg per dL versus 60.4 mg per dL, $P < 0.001$). Men exceeded women on TOTCHOL values (208.8 mg per dL versus 199.8 mg per dL), but the difference only approached significance ($P < 0.06$).

Mean TOTCHOL values for the entire sample were recomputed using the age categories of Blair and coworkers (*13*), and the results of the comparison are shown in figure 2. The pattern of cholesterol rising with age was the same in both samples except in those 50 and older; Blair and coworkers reported a continuing increase in total cholesterol values in this group as contrasted with a slight decrease in this study. Cholesterol levels in this study were approximately 5 to 10 percent higher than in the 1986 study in every age group.

Figure 3 presents mean cholesterol values across age groups for men and women. Because of small cell sizes, no data are presented for the 8 women older than 44 years, and the value for the 25 men in the 55 and older group should be interpreted cautiously. In the youngest age group, the mean for women (188 mg per dL) was slightly higher than that for men (182 mg per dL), but the means coincided at 201 mg per dL in the next oldest group. At that point, men's mean cholesterol values rose sharply to 220 mg per dL, while the women's ($N=96$) dropped slightly to 199 mg per dL. The men's level continued to rise to 230 mg per dL in the 45–54-year-old age group, and then dropped to 224 mg per dL in the oldest group.

The pattern for LDL-cholesterol was very similar (fig. 4), except that the men's mean surpassed the women's in the 25–34-year-old group and continued to rise to a peak of 151 mg per dL in the oldest group ($N=20$).

Prevalence of risk. Using the Navy's risk cutpoints for total cholesterol values (> 200 mg per dL for persons 18–24 years of age, and > 220 mg per dL for those 25 and older), overall prevalence of risk was computed. Results indicated that 36.9 percent of the sample were at risk for premature coronary heart disease because of elevated cholesterol. Again, the 41.5 percent at risk in the Lab 1 group was significantly higher than the 34.5 percent in the Lab 2 group ($P < 0.001$). Significant demographic

differences in prevalence of risk were found according to age, sex, education, and rank. The most striking differences occurred across age groups (18–24, 25–34, 35–44, 45–54, 55 and older); the percent at risk climbed from 25 percent in the youngest age group to 58 percent in the oldest ($P < 0.001$). Nearly 38 percent of all men were found to be at risk, compared to 28 percent of all women ($P < 0.001$). Among those with less than a high school education, prevalence of risk was 48 percent, whereas 36 percent were at risk among those with 12 years of school or more ($P < 0.001$). And though the observed difference was small, 38 percent of enlisted personnel were at risk compared with 35 percent of officers ($P < 0.04$). No significant differences were found for race or community (ship versus shore).

Overall percent at risk also was computed for each of the other lipid variables, with the following results: LDL ($\geq$ 130 mg per dL) = 48.4 percent at risk; HDL (< 35 mg per dL) = 9.1 percent; TRIG (> 250 mg per dL) = 8.3 percent; and TOTCHOL to HDL ratio (> 5.0) = 28.7 percent. Although triglyceride level and the TOTCHOL to HDL ratio generally are not independent predictors of cardiovascular risk, the LDL- and HDL-cholesterol fractions are both important independent risk factors. Therefore, prevalence of risk was recomputed, taking into account all three major factors: TOTCHOL, LDL, and HDL. The resulting cross-tabulation, based on the 3,829 people who had data for all three variables, is presented in table 3.

The overall percent with elevated TOTCHOL values (that is, at risk according to Navy cutpoints) in this subset was 34.8 percent. However, if those with desirable total cholesterol but elevated LDL- or low HDL-cholesterol were included in the risk calculation, an additional 19.4 percent would be considered at risk (13.7 percent plus 2.1 percent plus 3.6 percent), bringing the overall total to 54.2 percent. When a similar calculation was performed on the entire sample of 5,487, including those who had data for only one or two of the variables, 49.7 percent were found to be at risk on at least one of the three risk factors (25.2 percent on one, 22.2 percent on two, 2.3 percent on all three).

To explore further the variability of results obtained with different gauges of risk, the same total cholesterol values were analyzed using the three different sets of risk cutpoints outlined in table 1. Personnel of all ages (18–61) were included in this analysis. Figure 5 compares the percent of Navy personnel at risk when using the Navy

Figure 3. Mean total cholesterol values by age group and sex, U.S. Navy personnel, 1989

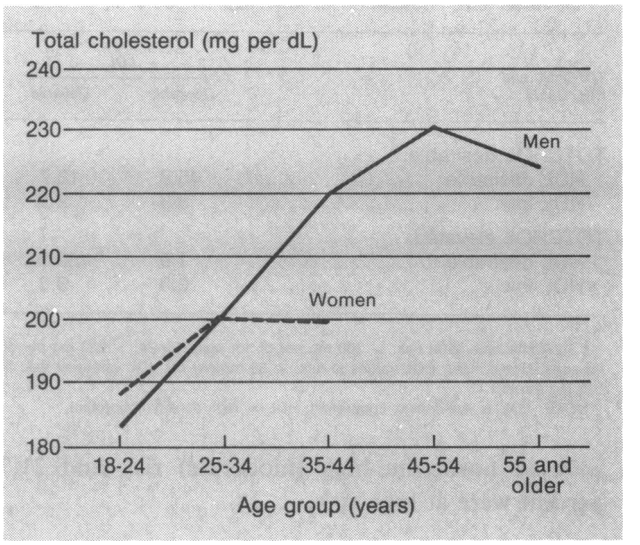
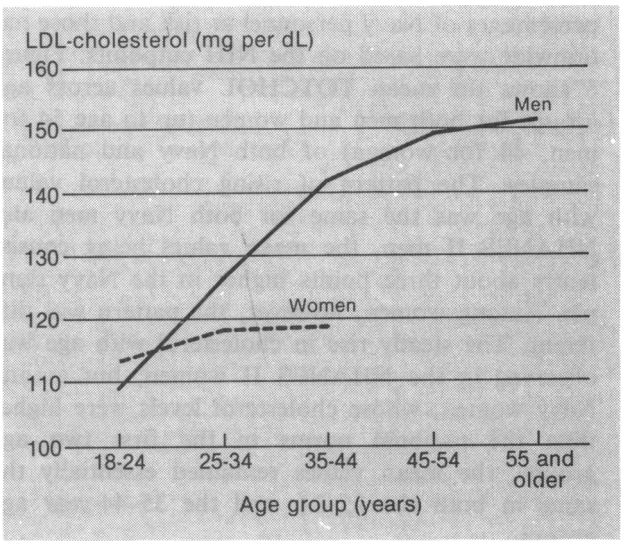


Figure 4. Mean low-density lipoprotein cholesterol, by age group and sex, U.S. Navy personnel, 1989



cutpoints with results obtained for the same sample when using the NIH and NCEP cutpoints. Although the 36.9 percent at risk according to the Navy standards was almost identical to the 36.3 percent at risk according to the NIH standards, it was considerably lower than the 55.4 percent obtained when using the NCEP cutpoints. The Navy makes no distinction between moderate and high risk levels, so all 36.9 percent at risk by Navy standards were arbitrarily assigned to the "moderate risk" category in figure 5. According to the NIH cutpoints, 15.8 percent of the Navy sample were at moderate risk and 20.5 percent were at high risk; using the NCEP guidelines, 33.7 percent

Table 3. Percentage of 3,829 Navy personnel at risk using Navy cutpoints[1] for elevated total cholesterol (TOTCHOL) and elevated LDL-cholesterol or low HDL-cholesterol, or both

TOTCHOL and HDL status	LDL	
	Desirable	Elevated
TOTCHOL desirable:		
HDL desirable	45.9	13.7
HDL low	3.6	2.1
TOTCHOL elevated:		
HDL desirable	1.9	29.3
HDL low	0.3	3.3

[1] TOTCHOL values at risk: > 200 mg per dL for ages 18–24, > 220 mg per dL for ages 25 and older; HDL values at risk: < 35 mg per dL; LDL values at risk: > 130 mg per dL.

NOTE: LDL = low-density lipoprotein; HDL = high-density lipoprotein.

were at borderline-high (moderate) risk and 21.7 percent were at high risk.

Comparisons with national norms. Because national norms derived from NHANES II used the NIH risk levels, the following comparisons between percentages of Navy personnel at risk and those nationwide were based on the NIH cutpoints. Figure 6 shows the mean TOTCHOL values across age groups for both men and women (up to age 54 for men, 44 for women) of both Navy and national samples. The pattern of rising cholesterol values with age was the same for both Navy men and NHANES II men, the mean values being consistently about three points higher in the Navy sample. Among women, however, the pattern was different. The steady rise in cholesterol with age was observed in the NHANES II women, but among Navy women, whose cholesterol levels were higher than the national norms in the first two age groups, the mean values remained essentially the same in both the 25–34- and the 35–44-year age groups.

In terms of the percentage at risk (NIH cutpoints), results again were very similar for men in the two samples but different for women. In both samples, fewest men were at risk in the youngest age group (24.9 percent Navy, 25.7 percent nation), while the peak percentage of men at risk, occurring at ages 35–44, was 38.5 percent for the Navy, and 37.6 percent for the nation. Among women, the pattern was reversed: the peak percentage at risk in both samples occurred in the youngest age group (38.3 percent Navy, 28.9 percent nation); the lowest percentage at risk was in the 35–44-year group (21.8 percent Navy, 27.4 percent nation).

The national sample of women exhibited a flat distribution across age groups as opposed to the Navy women's pronounced drop in the percentage at risk in the oldest group. (The relatively small sample sizes for Navy women should be borne in mind: 31 women at ages 20–24; 235 at ages 25–34; 96 at ages 35–44). When men and women ages 20–44 were combined and the two samples compared on total percent at risk, the Navy was significantly higher than the nation, with a total of 36.4 percent at risk versus the nation's 28.2 percent ($\chi^2(1) = 78.38$, $P < 0.001$).

When the Navy and national samples of persons ages 20–44 were compared on subgroup differences in percent at risk, similar patterns were observed. In both samples, percent at risk increased with age; it was higher among men than among women; and it was higher among those with less than a high school education, though after controlling for age, the difference was no longer significant in the national sample (comparative risk-by-education data were available only for persons in the high risk category).

Racial patterns differed between the two samples, however. In the Navy, significantly more blacks, 41.1 percent, were at risk than whites, 34.3 percent, while nationally, there was no significant race difference (29.4 percent of blacks at risk versus 30.4 percent of whites). (It will be recalled that no significant race difference was found for the Navy sample when using the Navy cutpoints.) Further analyses with the Navy data revealed no significant difference in mean TOTCHOL between blacks and whites—both groups had means of approximately 207 mg per dL—though the range for the 3,953 whites, 91–436 mg per dL, was broader than that for the 560 blacks, 102–338 mg per dL.

Discussion

In general, the serum cholesterol levels in this sample were somewhat elevated, the overall mean of 208 mg per dL being above the level recommended by the NCEP panel. Mean LDL-cholesterol also was above the recommended level for men, though not for women. It should be remembered that the sample was not demographically representative of the entire Navy, but only of persons undergoing routine physical examinations, and younger service members are underrepresented. If the sample, with a mean age of 33.6 years, were weighted to be age-representative of the entire Navy (mean age = 27.0), the overall mean cholesterol value would drop to 196 mg per dL. Such statistical adjustment was deemed inadvisable for

this report, however, because it is unknown to what extent the youngest participants, many of whose lipid profiles were drawn during medical or hardship discharge examinations, represented their peers remaining in the service.

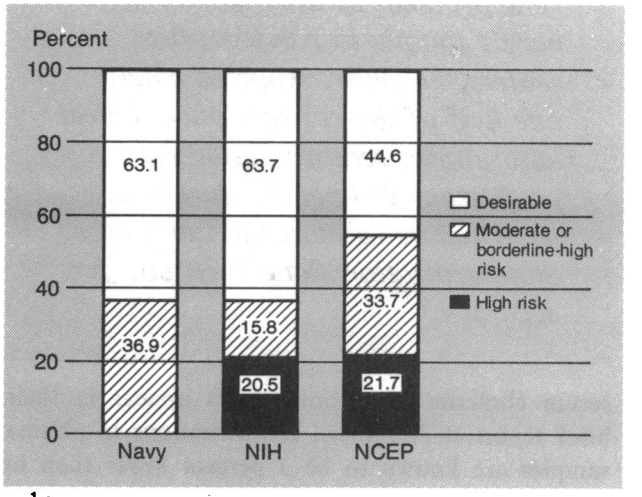
Women in the 34–44-year-old age group deviated from the overall pattern of increasing cholesterol values with age. Similarly, in a study of high blood pressure of Navy personnel, Nice and Trent (*14*) found an extremely low prevalence of hypertension among Navy women ages 35–44, a departure from the general pattern among Navy men and civilian men and women of increasing prevalence of hypertension with age. Further research could explore reasons for these findings. We know, for example, that Navy personnel exercise considerably more and evidence better weight control than the average American civilian (*15*, *16*); however, this is true of men as well as women. Another unexpected finding in this study was the racial difference in percent at risk on total cholesterol values (NIH cutpoints), which was not seen in the NHANES II sample. I am presently analyzing data concerning the dietary habits of Navy personnel, which may help explain these findings.

There was a significant difference in means between the two laboratories providing data for the study, although both exhibited means above 200 mg per dL. When the entire sample was compared to a 1986 Navy sample (*13*), TOTCHOL values were higher across all age groups than in the earlier study. These differences, both between samples and within the same sample, strongly suggest the methodological difficulties and lack of standardization that currently plague cholesterol testing. Lab 1 used a Technicon SMAC analyzer, which Blank and his coworkers (*17*) found to be positively biased with respect to the Lipid Research Clinics (LRC) standard results. Lab 2 used a Hitachi 736–30, which has not been evaluated, although a similar instrument, the Hitachi 737, was tested by Koch and his associates (*18*) and found to perform acceptably, that is, within the NCEP's currently recommended limits of 5 percent imprecision and 5 percent bias vis-a-vis the LRC method (*19*).

Although together these two studies imply a possible disparity in the accuracy of the two blood analyzers, a third instrument (the DuPont *aca*) was tested in both studies and also found to be positively biased by Blank and coworkers (*17*) but within acceptable error limits by Koch and associates (*18*), suggesting that the observed differences might be due to differences in the researchers' own methodologies rather than in the instruments themselves. When Kroll and his colleagues (*20*) corrected some of the methodological shortcomings that beset the study by Blank and coworkers (*17*) and repeated the tests of the SMAC and *aca*, they still found statistically significant positive bias in both instruments, but of a much smaller magnitude.

The mean cholesterol differences observed between this study and the 1986 Navy sample (*13*) also might be due to methodological discrepancies rather than real changes in Navy personnel's cholesterol values. It is possible that Blair and his colleagues measured plasma cholesterol rather than

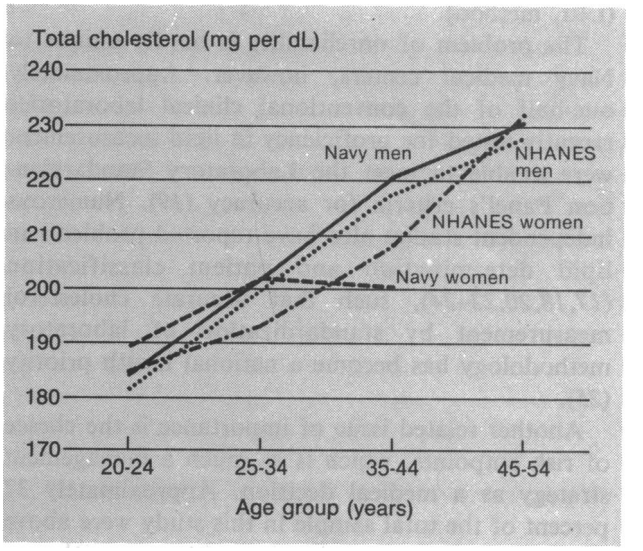
Figure 5. Percent of Navy personnel ages 18–61 years with total cholesterol levels at risk according to three sets of cutpoints[1]



[1] Cutpoints are defined in table 1.

NOTE: NIH = National Institutes of Health, 1984; NCEP = National Cholesterol Education Program, 1987.

Figure 6. Mean total cholesterol values by age and sex, U.S. Navy personnel compared with the general population, second National Health and Nutrition Examination Survey (NHANES II)



'The problem of unreliability is hardly unique to Navy medical centers, however. Approximately one-half of the conventional clinical laboratories recently tested for proficiency in lipid measurement were unable to meet the Laboratory Standardization Panel's criteria for accuracy.'

serum cholesterol, as both terms appear in their brief report. (Cholesterol concentrations in plasma samples are known to be 3 percent lower than in serum samples (*21*).) More importantly, their samples were processed at a different naval hospital than either of the laboratories in this study, and Navy lipid determination procedures have not been standardized, either across laboratories or against the Centers for Disease Control reference method (LRC method).

The problem of unreliability is hardly unique to Navy medical centers, however. Approximately one-half of the conventional clinical laboratories recently tested for proficiency in lipid measurement were unable to meet the Laboratory Standardization Panel's criteria for accuracy (*19*). Numerous independent studies also have reported problems in lipid determination and patient classification (*17,18,20,22-24*), such that accurate cholesterol measurement by standardization of laboratory methodology has become a national health priority (*25*).

Another related issue of importance is the choice of risk cutpoints, which is as much a management strategy as a medical decision. Approximately 37 percent of the total sample in this study were above the Navy risk cutpoints, and if LDL and HDL risk were counted as well, 54 percent would be considered at risk—about the same percentage as when using the NCEP cutpoint for total cholesterol alone.

One problem in choosing appropriate cutpoints is that cholesterol research is still young. The complex associations among various lipid factors, their interactions with demographic, genetic, or other risk factors, and their impact on coronary heart disease are not well understood. Prospective studies are needed to determine the impact of cholesterol guidelines on the population. Very different results are obtained using age-adjusted rather than uniform cutpoints, and results differ again if LDL or HDL risk levels, or both, are included in the calculation (*26*). The value of any given cutpoint strategy will depend in part on the relative percentages of resultant false positives and false negatives and on decisions that weigh the costs of each.

In attempting to develop their own cholesterol risk cutoff values for an Army sample (mean age of 39), Keniston and his associates (*27*) concluded that "the best combination of sensitivity and specificity (85 percent and 87 percent, respectively) occurred at a [total cholesterol] of 220 mg per dL." But if, on one hand, the cost of a false negative is higher than the cost of a false positive, the "best combination" may not be an equal balance but rather one that favors sensitivity. On the other hand, if half of the population is determined to be at risk, health providers responsible for intervention and treatment must set priorities and ask, "How much risk?"

The practice of classifying persons into "moderate" ("borderline-high") and "high" risk categories helps guide treatment decisions as well as alerting patients to their own risk status; it should perhaps be adopted by the Navy. Yet Belsey and Baer (*28*) argue that the current level of inaccuracy, imprecision, and biological variation in cholesterol measurement make such refined discrimination problematic. Instead, they recommend classifying only those patients whose cholesterol levels are clearly high (or clearly low), taking into account the full range of variability (for example, ±5 percent) surrounding a given person's cholesterol value, while continuing to monitor patients whose ranges fall into the gray "borderline" area until clear patterns emerge.

Public concern about cholesterol and its potential health effects has increased tremendously, but the predictable backlash (*29*), in conjunction with recent reports of inaccuracies in the measurement of serum cholesterol, could destroy public confidence in even the most sensible recommendations by such agencies as the NCEP. Continued careful research and general procedural standardization will help dispel confusion and provide the foundation for optimal screening and treatment programs.

References

1. 1989 heart facts. National Center, American Heart Association, Dallas, TX, 1988.
2. Lipid Research Clinics Program: The Lipid Research Clinics Coronary Primary Prevention Trial results: I. Reduction in the incidence of coronary heart disease. JAMA

148: 351-364, Jan. 20, 1984.
3. Atherosclerosis Study Group: Optimal resources for primary prevention of atherosclerotic diseases. Circulation 70: 157A-205A, July 1984.
4. Castelli, W. P., et al.: Incidence of coronary heart disease and lipoprotein cholesterol levels: the Framingham study. JAMA 256: 2835-2838, Nov. 28, 1986.
5. Kannel, W. B., Castelli, W. P., and Gordon, T.: Cholesterol in the prediction of atherosclerotic disease. Ann Intern Med 90: 85-91, January 1979.
6. Shekelle, R. B., et al.: Diet, serum cholesterol, and death from coronary heart disease: the Western Electric study. N Eng J Med 304: 67-70, Jan. 8, 1981.
7. Stamler, J., Wentworth, D., and Neaton, J.: Is the relationship between serum cholesterol and risk of death from CHD continuous and graded? JAMA 256: 2823-2828, Nov. 28, 1986.
8. Consensus Conference: Lowering blood cholesterol to prevent heart disease. JAMA 253: 2080-2086, Apr. 12, 1985.
9. Fulwood, R., et al.: Total serum cholesterol levels of adults 20-74 years of age, United States 1976-80. Vital Health Stat [11] No. 236. DHHS Publication No. (PHS) 86-1686. U.S. Government Printing Office, Washington, DC, May 1986.
10. The Expert Panel: Report of the National Cholesterol Education Program Expert Panel on detection, evaluation, and treatment of high blood cholesterol in adults. Arch Intern Med 148: 36-69, January 1988.
11. Sempos, C., et al.: The prevalence of high blood cholesterol levels among adults in the United States. JAMA 262: 45-52, July 7, 1989.
12. Department of the Navy: Physical exams. SECNAV Msg DTG R 0120457 JUN 89. Office of the Secretary of the Navy, Washington, DC, June 1989.
13. Blair, T. P., Marghella, P. D., Landers, R., and Boccuzzi, N. C.: Incidence of hypercholesterolemia in the active duty Navy population in 1986. Milit Med 154: 29-31, January 1989.
14. Nice, D. S., and Trent, L. K.: Prevalence of hypertension among active-duty Navy personnel. Report No. 90-5. Naval Health Research Center, San Diego, CA, 1990.
15. Conway, T. L., Trent, L. K., and Conway, S. W.: Physical readiness and lifestyle habits among U.S. Navy personnel during 1986, 1987, and 1988. Report No. 89-24. Naval Health Research Center, San Diego, CA, 1989.
16. Nice, D. S., and Conway, T. L.: Exercise patterns in the U.S. Navy. Report No. 88-1. Naval Health Research Center, San Diego, CA, 1988.
17. Blank, D. W., Hoeg, J. M., Kroll, M. H., and Ruddel, M. E.: The method of determination must be considered in interpreting blood cholesterol levels. JAMA 256: 2867-2870, Nov. 28, 1986.
18. Koch, D. D., Hassemer, D. J., Wiebe, D. A., and Laessig, R. H.: Testing cholesterol accuracy: performance of several common laboratory instruments. JAMA 260: 2552-2557, Nov. 4, 1988.
19. Laboratory Standardization Panel of the National Cholesterol Education Program: Current status of blood cholesterol measurement in clinical laboratories in the United States. Clin Chem 34: 193-201, January 1988.
20. Kroll, M. H., et al.: Bias between enzymatic methods and the reference method for cholesterol. Clin Chem 34: 131-135, January 1988.
21. Laboratory Methods Committee of the Lipid Research Clinics Program of the National Heart, Lung, and Blood Institute: Cholesterol and triglyceride concentrations in serum/plasma pairs. Clin Chem 23: 60-63 (1977).
22. Kaufman, H. W., et al.: How reliably can compact chemistry analyzers measure lipids? JAMA 263: 1245-1249, Mar. 2,1990.
23. Naughton, M. J., Luepker, R. V., and Strickland, D.: The accuracy of portable cholesterol analyzers in public screening programs. JAMA 263: 1213-1217, Mar. 2, 1990.
24. Woolf, S. H.: Elevated serum cholesterol in asymptomatic adults. *In* Preventing disease: beyond the rhetoric, edited by R. B. Goldbloom and R. S. Lawrence. Springer-Verlag, New York, 1990, pp. 401-411.
25. Rosenfeld, L.: Atherosclerosis and the cholesterol connection: evolution of a clinical application. Clin Chem 35: 521-531, April 1989.
26. Wones, R. G., et al.: Comparisons of referral criteria for public screening of blood cholesterol levels. Public Health Rep 104: 425-432, September-October 1989.
27. Keniston, R. C., Weir, M. R., Enriquez, J., and Duncan, F.: The Sergeant Major Study: health risk assessment by clinical laboratory parameters. DTIC Technical Report No. AD-A203-102. Army Science Conference Proceedings, vol. 2. Defense Logistics Agency, Defense Technical Information Center, Alexandria, VA, October 1988, p. 53.
28. Belsey, R., and Baer, D. M.: Cardiac risk classification based on lipid screening. JAMA 263: 1250-1252, Mar. 2, 1990.
29. Moore, T. J.: The cholesterol myth. The Atlantic 264: 37-70, September 1989.