Prevalence of Dyslipidemia and Mean Blood Lipid Values in Taiwan: Results from the Nutrition and Health Survey in Taiwan (NAHSIT, 1993-1996)

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Abstract

This paper reports the blood lipid status of people aged 4 years and older in Taiwan. The data is based on the Nutrition and Health Survey in Taiwan (NAHSIT: 1993-1996), which adopted a multi-stage, stratified clustering sampling scheme. Altogether, 5097 subjects (2451 males and 2646 females) had data on triglyceride and 5643 subjects (2736 males and 2907 females) had data on cholesterol. We found that (a) cholesterol levels of males were lower than females in mid-to old age group (≥ 45 years old); (b) triglyceride values of females were lower than males in young adulthood (19~44 years), but higher than males after the age of 45 years, and (c) adult females had higher HDL-C value and lower ratio of total cholesterol to HDL-C than males. The prevalence of hypercholesterolemia was 10.2% in adult males and 12.6% in mid-to-old aged men, and that in females was 11.2% and 24.4%, respectively. The prevalence of hypertriglyceridemia was 13.4% and 6.1% in adult males and females (≥ 19 years as a whole), respectively. It was 12.3% in mid-to-old aged men (≥ 45 years), and 11.9% in women.

The mean cholesterol values were similar to values of several previous surveys in different areas of Taiwan. But it was higher than those in some areas of Mainland China, and lower than those of western countries. People in metropolitan cities had a higher level of blood cholesterol than other areas. The average triglyceride values of males and females were higher than those of previous studies in Taiwan and of people in Mainland China. Mountainous stratum with predominantly aboriginal residents had higher level of triglycerides and body mass index (BMI) than other strata.

The associations between dietary intakes of men and women and blood lipids were examined controlling for age and BMI. Result showed that Keys score, which was derived from saturated fat, polyunsaturated fat and dietary cholesterol of a 24-hour recall, was positively related to blood cholesterol and LDL-C in men, but not in women. Average alcohol intakes per day were related to HDL-C positively, but LDL-C negatively in men and women. The regional differences in blood lipid profiles in Taiwan are consistent with the dietary and life-style variations island-wide.

Key Words: triglycerides, cholesterol, HDL-C, LDL-C, alcohol, keys score, Taiwan

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Introduction

Due to the economic growth and increasing popularity of western foods, dietary pattern of people in Taiwan is at the stage of rapid transformation. In the past, mortality rate of coronary heart diseases in Taiwan was in the low extreme of the world (17), possibly due to high intakes of foods of plant sources. However, age standardized death rate of coronary heart diseases has been increasing slowly, but steadily in the past 20 years (3). The increase is particularly apparent in the younger age group (21). Whether the increase is related to the changes of diet and the impact of the recent westernization are worth of close investigation. Dyslipidemia is one of the most important risk factors of artherosclerosis (24), which is also highly associated with dietary pattern. Composition of fatty acid and levels of cholesterol, fiber and vitamins in diet are among the major dietary elements determining the quality and concentration of serum lipid (10,13,19). This paper presents the values of total serum cholesterol, HDL-Cholesterol (C), lipoprotein LDL-C, ratio of total cholesterol to HDL-C, triglycerides and prevalence of dyslipidemia in people of Taiwan by sex, age groups and geographical locations and how they were associated with dietary factors.

Materials and Methods

The data used in this study was from the Nutrition and Health Survey in Taiwan (NAHSIT: 1993-1996). This survey divided 359 towns and districts of Taiwan into 7 strata according to the dietary pattern, geographical location, and urbanization index. These 7 strata were Hakka, mountainous area, East Coast, Peng-Hu islands, metropolitan cities, provincial cities and urbanization class I townships, and urbanization class II townships. Three townships were selected in each stratum with the selection probability proportional to its population size (PPS). Three villages (or li's, the smallest district) were selected in each township using PPS method. People in each village were further divided into 7 age groups and 2 sex groups. Eight or 16 individuals were sampled in each age by sex group. According to a pseudo-Latin square design, the three villages were surveyed in different seasons during the three-year survey period in a season-balanced manner. The interview team stayed in each village for 3 weeks to conduct door-to-door interview. Medical workers joined the team on the third and the fourth Sundays for the physical examinations, which included overnight urine collection, fasting blood drawing, anthropometry, elecrocardiogram, and oral glucose tolerance tests etc. Detailed operations have been described previously (4).

The variables included in this paper were from both the questionnaires and physical examinations. Information on demography and medication were obtained from questionnaires. Blood samples were drawn in the morning after a longer than 8 hour fast and were centrifuged on site. Serum was frozen in dry ice and sent back to Academia Sinica to be stored in - 70°C on the day of collection. Serum was analyzed within a month for triglycerides, total cholesterol, HDL-C using Hitachi model 747 automatic analyzer. The coefficients of variation derived from 5.0% split sample, were 3.0% for triglycerides, 3.1% for total cholesterol, and 9.4% for HDL-C. Those who reported to take medicine to lower blood lipids (1.5% of males and 2.2% of females) were excluded from calculating mean values. But they were considered as having dyslipidemia in the analyses of prevalence.

The LDL-C and the ratio of total cholesterol to HDL-C were calculated as follows: LDL-C[total cholesterol - (HDL-C)-triglycerides/5], ratio of total cholesterol to HDL-C(total cholesterol / HDL-C).

The definitions of dyslipidemia include:
serum triglycerides ≥ 2.26 mM or on medication,
total serum cholesterol ≥ 6.21 mM or on medication,
serum HDL-C < 0.91 mM,
serum LDL-C ≥ 4.14 mM, and
ratio of total cholesterol to HDL-C ≥ 5.

For people aged between 13 and 64, intakes of nutrients were collected using 24-hour recall methods. Data on 24-hour recalls were collected inside households. Following a standardized protocol, interviewers used Chinese food piece models, abstract food models, and electronic weight to aid the chef of the household to recall the kinds and quantity of food they cooked and the recipes they used in the past 24 hours. Then, collected information on the kinds and the quantity of food the chef personally and the individual family members consumed and information on the time and place of eating to construct the 24-hour recall diet at the individual level (16). All data were coded and entered on site in a computer aided fashion to avoid missing or errors in data. Taiwan nutrient data bank were used to calculated nutrient intake levels (5). Relationships between total cholesterol and intakes of fat, fatty acid, alcohol, total energy and keys score were examined. Keys score was calculated from the following formula (12):

$$\text{Keys score}=1.3 \times (2S-P)+1.5\sqrt{CHOL/E \times 1000}$$

where S is the percentage of calories obtained from saturated fat, P is the percentage of calories from polyunsaturated fat, CHOL is the cholesterol intake

Table 1. The Mean and Standard Error of Cholesterol, HDL-C, LDL-C, the Ratio of Cholesterol to HDL-C, and Triglycerides by Age Groups and Sex. All the Values Have Been Weighed by Sampling Weights.

Sex	Age Group (years)	Sample Sizes	Cholesterol (mM) Mean	s.e	LDL-C (mM) Mean	s.e.	HDL-C (mM) Mean	s.e.	Ratio[1] Mean	s.e.	TG (mM) Mean	s.e.
Males	4-6	236	4.36*	0.09	2.50*	0.06	1.50*	0.05	3.08	0.06	0.77	0.05
	7-12	652	4.34*	0.05	2.36*	0.05	1.65*	0.05	2.80*	0.10	0.71	0.03
	13-18	499	3.99	0.06	2.21	0.06	1.43	0.04	2.99	0.08	0.75	0.02
	19-44	469	4.89*	0.05	2.84*	0.07	1.42	0.03	3.77*	0.08	1.37*	0.05
	45-64	548	5.11*	0.09	3.07*	0.07	1.37	0.04	4.11*	0.07	1.46*	0.08
	65 +	278	5.13*	0.14	3.17*	0.14	1.44	0.04	3.87*	0.15	1.13*	0.03
	subtotal	2682	4.76	0.04	2.77	0.04	1.44	0.03	3.62	0.07	1.20	0.03
	≥ 19	1295	4.96	0.05	2.93+	0.04	1.41+	0.03	3.86+	0.07	1.36+	0.04
	≥ 45	826	5.11+	0.09	3.10+	0.08	1.39+	0.04	4.03	0.08	1.35+	0.05
Females	4-6	239	4.57*	0.10	2.64*	0.07	1.57	0.06	3.10	0.10	0.79	0.05
	7-12	631	4.35	0.02	2.40	0.06	1.55	0.04	2.99	0.08	0.86	0.03
	13-18	564	4.33	0.07	2.40	0.07	1.57	0.05	2.93	0.07	0.80	0.03
	19-44	584	4.58*	0.08	2.54*	0.06	1.61	0.03	3.07	0.07	0.94*	0.05
	45-64	581	5.46*	0.09	3.26*	0.08	1.55	0.04	3.88*	0.11	1.41*	0.07
	65 +	260	5.44*	0.14	3.28*	0.10	1.46*	0.04	4.01*	0.09	1.54*	0.10
	subtotal	2859	4.74	0.07	2.69	0.05	1.58	0.02	3.25	0.06	1.03	0.03
	≥ 19	1425	4.86	0.08	2.77	0.07	1.58	0.03	3.35	0.08	1.11	0.04
	≥ 45	841	5.45	0.10	3.26	0.08	1.53	0.03	3.92	0.10	1.45	0.06

1. Ratio of cholesterol to HDL-C
* Significantly different from people aged between 13 and 18 years, α=0.05.
+ Significantly different from females in the same age group, α=0.05.

(mg), and E is the total energy intakes.

All the data were weighed to represent the population. All the data analyses were carried out using SAS version 8.0 (20) and SUDAAN (22). Mean, standard deviation of lipids and prevalence of abnormal lipids were reported by sex, age groups and strata in this paper. Comparisons were made by t-test accounting for design effects of the complex sample scheme. Further more, linear regression was used to examine the relationships between dietary factors and blood cholesterol, LDL-C and HDL-C. Since our interest was the relationship, no weight was used in linear regression.

Results

The age-sex specific means of serum cholesterol, LDL-C, HDL-C, ratio of cholesterol to HDL-C and triglycerides are presented in Table 1. Overall, the levels of cholesterol, LDL-C, ratio of cholesterol to HDL-C, and triglycerides in adults increased as age increased except the triglyceride levels of the older males (≥65 years). The serum cholesterol levels of females were in general higher than those of males except the young adulthood (19 to 44 years old). In both men and women, the lowest cholesterol value appeared in those aged between 13 and 18 years (Table 1). The cholesterol levels increased rapidly after 45 years old. Females aged 45 and over had significantly higher level of cholesterol than their male counterparts. Very similar trends were found in LDL-C (Table 1).

The highest level of HDL-C in men was observed in those aged between 7 and 12 years. It leveled off after age group of 13 to 18. Age trends of HDL-C were not noticeable in female, except the oldest women had the lowest level. Adult (≥ 19 years old) and mid-to-old aged (≥ 45 years old) males had significantly lower levels of HDL-C than their female counterparts. The trends in cholesterol and HDL-C resulted in the trend in the ratio of cholesterol to HDL-C: younger age groups had lower ratio than older age groups, and adult males had higher ratio than females.

Triglyceride levels of women increased as age increased. The elderly (≥ 65 years) had the highest level of triglycerides. On the other hand, men aged between 45 and 64 had the highest level of triglycerides among men in all the age groups. Adult (≥ 19 years) males had higher level of triglycerides than adult females, whereas mid-to-old age men (≥ 45 years) had lower level of triglycerides than mid-to-old age women.

Table 2. The Mean and Standard Error of Cholesterol, HDL-C, LDL-C, the Ratio of Cholesterol to HDL-C, and Triglycerides of Adults (≥ 19 years) in Taiwan by Sex and Geographical Locations. All the Values Have Been Weighed by Sampling Weights.

Sex	Geographical locations	Sample size	Cholesterol (mM) Mean	s.e	LDL-C (mM) Mean	s.e.	HDL-C (mM) Mean	s.e.	Ratio Mean	s.e.	TG (mM) Mean	s.e.	BMI Mean	s.e.
Males	Hakka area	187	4.89	0.07	2.80	0.07	1.47^{+}	0.07	3.62^{+}	0.12	1.36	0.05	22.9	0.1
	Mountainous area	196	4.77*	0.05	2.59*	0.07	1.30^{+}	0.05	4.15*$^{+}$	0.21	1.90*	0.08	25.4*	0.3
	East Coast area	195	5.01	0.10	2.75	0.12	1.40^{+}	0.04	3.97	0.21	1.88*	0.22	23.5*	0.4
	Peng-Hu islands	174	4.85*	0.08	2.92	0.09	1.37^{+}	0.04	3.75	0.16	1.23*	0.08	22.9	0.2
	Metropolitan cities	195	5.05	0.04	2.92	0.04	1.44^{+}	0.07	3.91	0.18	1.50^{+}	0.09	23.0^{+}	0.2
	Provincial cities and class I townships	168	4.96	0.11	2.97	0.08	1.41^{+}	0.06	3.85	0.11	1.26*	0.04	23.0	0.5
	Class II townships	180	4.93*	0.02	2.91	0.08	1.40^{+}	0.02	3.86	0.10	1.36	0.09	22.8	0.4
Females	Hakka area	200	4.92	0.05	2.72	0.03	1.71	0.06	3.13	0.07	1.05	0.03	22.6	0.2
	Mountainous area	222	4.80*	0.09	2.48*	0.04	1.51*	0.04	3.52*	0.12	1.77*	0.26	26.3*	0.5
	East Coast area	211	4.89	0.08	2.72	0.10	1.55	0.05	3.48	0.22	1.34*	0.08	23.5*	0.3
	Peng-Hu islands	205	5.03	0.08	2.98	0.07	1.53	0.04	3.56*	0.09	1.13	0.06	23.5	0.4
	Metropolitan cities	193	5.07	0.05	2.77	0.07	1.76	0.11	3.24	0.25	1.16	0.10	22.2	0.3
	Provincial cities and class I townships	185	4.91	0.13	2.82	0.12	1.60	0.02	3.30	0.10	1.06	0.06	23.4	0.2
	Class II townships	209	4.69*	0.15	2.73	0.13	1.45*	0.01	3.47	0.16	1.10	0.08	23.0	0.3

*Significantly different from metropolitan cities at α=0.05 level
$^{+}$ Significantly different from females at α=0.05 level

When comparing the lipid profiles of adults (≥ 19 years) across different stratum, the cholesterol levels of people in the mountainous area and class II townships had significantly lower values than those in the metropolitan area (Table 2). Men in Peng-Hu islands had significantly lower cholesterol levels than those in metropolitan cities too. Both males and females in mountainous area had significantly higher levels of LDL-C than people lived in metropolitan cities. Women in mountainous area and class II townships had significantly lower levels of HDL-C than women in metropolitan cities. Both men and women in mountainous area had higher levels of the ratio of cholesterol to HDL-C than people in metropolitan cities. Women in Peng-Hu islands had significantly higher ratio than metropolitan women too. Both men and women in mountainous area and east coast had the higher levels of triglycerides than those in metropolitan cities (Table 2), whereas men in Peng-Hu islands and class I townships had significantly lower levels of triglycerides than men in metropolitan cities. The patterns in people from the mountainous area and the east coast were consistent with their mean values of BMI (Table 2).

Table 3 shows the prevalence of dyslipidemia by age and sex. Men aged between 45 and 64 had significantly lower prevalence of hypercholesterolmia than women in the same age group. Mid-to-old age women (≥ 45 years) had significantly higher prevalence of hypercholesterolmia than their male counterparts. Men aged between 45 and 64 had significantly higher prevalence of low HDL-C than women of the same age. Thus, the ratio of total cholesterol to HDL-C was worse in males than females of the same age group, even at younger age group (19~44 years). The prevalence of hypertriglyceridemia was significantly higher in males aged between 19 and 44, and between 45 and 64 years than females of the same age group. Adult males as a whole had significantly higher prevalence of hypertriglyceridemia than females.

Table 4 shows the prevalence of dyslipidemia in different geographical locations. Table 5 shows the standardized prevalence of dyslipidemia. The results were standardized to 1980 US population. Adult males of mountainous area and Peng-Hu islands had lower prevalence of hypercholesterolemia than those in metropolitan cities. Women in Hakka, mountainous areas and East Coast, had significantly lower prevalence of hypercholesterolemia than those in metropolitan cities (Table 5). Men and women in east coast area had significantly lower prevalence of high LDL-C than those in the metropolitan cities. The prevalence of low HDL-C, ratio of cholesterol to

Table 3. Prevalence and 95% Confidence Interval of Dyslipedemia by Age and Sex.

Sex	Age Group (years)	Hypercholecemia %	(CI)	High LDL-C %	(CI)	Low HDL-C %	(CI)	High Ratio %	(CI)	Hypertriglycemia %	(CI)
Males	4-6	2.2	(0.0, 6.1)	1.6*	(0.0, 4.2)	6.9	(3.8, 10.0)	1.9	(1.2, 2.7)	2.4	(0.0, 5.8)
	7-12	0.9	(0.0, 2.2)	0.4	(0.0, 1.0)	4.0	(1.2, 6.7)	1.7	(0.0, 3.6)	0.7	(0.0, 1.9)
	13-18	1.9	(0.6, 2.9)	2.1	(0.6, 2.9)	10.1	(4.6, 16.0)	3.5	(1.8, 5.2)	0.1	(0.0, 0.2)
	19-44	8.8	(3.9, 14.0)	7.2	(4.6, 10.1)	11.0	(6.7, 16.5)	14.3*	(10.5, 17.4)	13.9*	(8.8, 19.0)
	45-64	12.2*	(8.2, 17.9)	11.6	(6.9, 16.5)	16.3*	(9.3, 22.4)	21.7*	(17.8, 24.1)	17.7*	(11.1,24.2)
	65 +	13.0	(7.5, 18.8)	14.8	(8.0, 22.3)	11.0	(3.8, 18.8)	18.1	(7.9, 29.2)	1.2*	(0.2, 1.6)
	≥ 19	10.2	(6.8, 13.6)	9.2	(7.3, 10.6)	12.2	(7.1, 17.3)	16.5*	(12.9, 19.2)	13.4*	(10.1, 16.6)
	≥ 45	12.6*	(9.6, 15.6)	12.8	(9.8, 15.9)	14.4	(8.1, 20.7)	20.2	(15.1, 25.2)	12.3	(8.1, 16.4)
Females	4-6	8.1	(3.2, 13.0)	8.2	(4.2, 12.2)	3.6	(0.0, 7.6)	3.1	(0.0, 6.3)	1.0	(0.0, 2.8)
	7-12	1.3	(0.8, 2.6)	0.8	(0.1, 1.5)	7.0	(4.6, 9.8)	3.1	(2.2, 4.2)	1.2	(0.0, 2.5)
	13-18	0.8	(0.0, 1.9)	1.1	(0.0, 2.4)	4.0	(1.3, 6.4)	1.6	(0.0, 3.4)	0.3	(0.0, 0.7)
	19-44	4.7	(2.1, 7.5)	3.5	(1.6, 5.6)	6.7	(3.5, 10.1)	4.7	(1.9, 7.7)	3.7	(1.5, 4.9)
	45-64	24.3	(13.6, 35.0)	18.7	(8.2, 29.0)	8.0	(3.8, 12.4)	16.0	(13.7, 18.7)	11.2	(8.4, 14.2)
	65 +	24.8	(16.8, 32.8)	13.6	(4.6, 20.7)	12.9	(8.2, 17.7)	18.0	(13.4, 22.5)	13.4	(6.5, 19.6)
	≥ 19	11.2	(6.4, 15.9)	8.0	(3.9, 12.1)	7.7	(4.6, 10.8)	8.7	(6.4, 10.9)	6.1	(5.0, 7.1)
	≥ 45	24.4	(15.3, 33.5)	17.2	(8.1, 26.2)	9.5	(6.1, 12.9)	16.7	(14.1, 19.3)	11.9	(9.7, 14.1)

* Significantly different from females. (α=0.05)

HDL-C and hypertriglycemia in most of the strata were not significantly different from that in metropolitan cities, except that the prevalence of high ratio of cholesterol to HDL-C of women in mountainous areas was significantly higher. Men in Hakka areas and metropilitan cities had significantly higher prevalence of low HDL-C, high ratio of cholesterol to HDL-C, and hypertriglyceridemia than their female counterparts. Males in mountainous areas had significantly higher prevalence in high LDL-C, low HDL-C and high ratio of cholesterol to HDL-C than women in the same areas. Men in east coast area had significantly higher prevalence in high ratio of cholesterol to HDL and hypertriglycemia than women in the same area.

Table 6 shows the average intakes of total energy, fat (both the absolute value and % of calories), saturated fatty acid, polyunsaturated fatty acid, P/S ratio and Keys score for those who completed the 24-hr-recall. The intakes of total energy and fat in most areas were not significantly different from those in metropolitan areas. Men in Hakka area and class II townships had significantly higher percent fat intake than men in metropolitan cities. Men in mountainous area, and Peng-Hu islands had significantly higher levels of P/S ratio than those in metropolitan cities. Similarly, women in Peng-Hu islands had significantly higher level of P/S ratio than those in metropolitan cities. Men and women in Peng-Hu islands had significantly lower Keys scores than those in metropolitan cities. Women in mountainous area also had lower keys scores than those in metropolitan cities. The difference between men and women in intakes energy, saturated fatty acid, percent fat of energy and P/S ratio were apparent.

Table 7 shows the relationships between each item and blood lipids controlling for age and BMI. Since our interests were the relationships between dietary factors and blood lipids, no weights were used in models. Dietary cholesterol was significantly associated with triglycerides in men. The relationships between dietary cholesterol and LDL-C or HDL-C were significant at borderline, (p was between 0.05 and 0.1). Keys score, which accounts for saturated fatty acid, polyunsaturated fatty acid and dietary cholesterol, was positively related to cholesterol and LDL-C in males. Saturated fatty acid (SFA) was positively related to LDL-C in males. Polyunsaturated fatty acid (PUFA) was associated with triglycerides negatively in males, and negatively associated with blood cholesterol in females. It was associated with LDL-C of females with borderline significance. Alcohol intake was associated with LDL-C negatively, positively associated with HDL-C and triglycerides in both males and females..

Discussion

In Taiwan, females had better blood lipid status than males at the ages between 19 and 44 years in Taiwan. The differences between males and females leveled off at the ages between 45 and 64 years. Then,

Table 4. Prevalence and 95% Confidence Interval of Dyslipidemia of Adults (≥ 19 years) in Taiwan by Geographic Locations. All the Values Have Been Weighed by Sampling Weights Derived for the Physical Examination.

Sex	Geographical locations	N	Hypercholesterol-emia % (CI)	High LDL-C % (CI)	Low HDL-C % (CI)	High Ratio % (CI)	Hypertriglycemia % (CI)
Males	Hakka area	187	11.5 (7.1, 15.8)	9.2+ (6.5, 11.9)	8.4+ (5.4, 11.4)	11.8+ (9.5, 14.1)	14.0+ (11.1, 16.9)
	Mountainous area	196	6.6* (1.9, 11.4)	7.7 (4.2, 11.1)	17.3*+ (13.5, 21.1)	22.9+ (15.7, 30.1)	23.4 (20.0, 26.8)
	East Coast area	195	11.4 (7.0, 15.8)	5.0* (1.3, 8.6)	10.1 (4.9, 15.3)	21.3+ (13.2, 29.4)	23.0+ (18.8, 27.3)
	Peng-Hu islands	174	6.3+ (3.7, 8.9)	7.0 (3.3, 10.8)	9.0 (5.1, 13.0)	13.4 (6.3, 20.5)	6.8* (2.9, 10.6)
	Metropolitan cities	195	13.1 (10.3, 15.8)	12.1 (6.3, 17.8)	9.8 (4.3, 15.2)	17.4+ (8.7, 26.1)	18.6+ (10.2, 27.0)
	Provincial cities and class I townships	168	8.7 (3.0, 14.4)	8.8 (7.6, 10.1	13.9 (2.4, 25.4)	15.0 (9.8, 20.1)	10.4 (4.3, 16.5)
	Class II townships	180	10.3 (3.6, 17.1)	8.4 (6.8, 9.9)	11.9 (7.2, 16.7)	16.4 (11.8, 21.1)	13.1+ (9.0, 17.1)
Females	Hakka area	200	9.4 (5.2, 13.6)	4.7 (0.7, 8.7)	2.1 (0.0, 4.5)	5.9 (2.2, 9.6)	7.1 (3.7, 10.5)
	Mountainous area	222	9.7 (4.2, 15.2)	3.7 (0.0, 7.7)	11.1* (8.5, 13.8)	13.5* (9.3, 17.6)	23.7* (10.8, 36.6)
	East Coast area	211	7.4* (3.9, 10.9)	5.5 (3.7, 7.3)	7.4 (1.9, 12.9)	10.1 (2.2, 18.0)	9.8 (3.4, 16.1)
	Peng-Hu islands	205	11.8 (8.0, 15.5)	10.7 (7.3, 14.1)	6.2 (3.2, 9.1)	11.3 (7.2, 15.5)	7.1 (3.8, 10.4)
	Metropolitan cities	193	13.5 (10.3, 16.6)	8.5 (6.5, 10.6)	3.9 (0.0, 8.5)	6.1 (2.5, 9.8)	8.0 (3.8, 12.1)
	Provincial cities and class I townships	185	10.3 (0.9, 19.7)	7.9 (0.6, 16.4)	6.2 (4.2, 8.1)	8.3 (3.5, 13.1)	4.5 (3.3, 5.6)
	Class II townships	209	11.3 (3.8, 18.8)	8.2 (2.2, 14.2)	12.2 (3.6, 20.8)	10.7 (8.4, 13.0)	6.2 (4.5, 7.9)

* Significantly different from metropolitan cities at α=0.05 level
+ Significantly different from females at α=0.05 level

Table 5. Age Standardized Prevalence and 95% Confidence Interval of Dyslipidemia of Adults (≥ 19 years) in Taiwan by Geographic Locations. All These were Standardized to 1980 US Population.

Sex	Geographical locations	N	Hypercholesterolemia % (CI)		High LDL-C % (CI)		Low HDL-C % (CI)		High Ratio % (CI)		Hypertriglycemia % (CI)	
Males	Hakka area	187	11.4	(7.1, 15.7)	9.4^{+}	(5.6, 13.2)	9.8^{+}	(6.3,13.4)	12.5^{+}	(9.8, 15.2)	14.7^{+}	(11.9, 17.5)
	Mountainous area	196	8.0*	(4.5, 11.5)	10.0^{+}	(7.7, 12.2)	17.9^{+}	(14.3, 21.5)	23.7^{+}	(17.5, 30.0)	22.1	(18.8, 25.5)
	East Coast area	195	11.0	(6.4, 15.6)	4.8*	(1.3, 8.5)	10.5	(6.0, 15.1)	20.6^{+}	(12.3, 28.8)	23.9^{+}	(20.7, 25.6)
	Peng-Hu islands	174	6.8^{*+}	(4.2, 9.3)	7.4	(3.9, 10.8)	9.0	(5.3, 12.7)	13.6	(7.0, 20.3)	6.9	(3.3, 10.5)
	Metropolitan cities	195	13.0	(10.1, 15.8)	12.1	(7.2, 17.1)	10.0^{+}	(3.7, 16.3)	17.4^{+}	(8.5, 26.4)	17.9^{+}	(8.6, 27.3)
	Provincial cities and class I townships	168	8.4	(3.8, 13.0)	9.0	(7.6, 10.3)	13.9	(2.9, 25.0)	14.8	(8.9, 20.6)	8.9	(4.7, 13.0)
	Class II townships	180	10.8	(4.8, 16.7)	10.3	(9.2, 11.4)	13.0	(5.3, 20.6)	17.1	(10.8, 23.4)	11.8	(8.0, 15.6)
Females	Hakka area	200	10.8*	(5.9, 15.7)	5.3	(1.6, 8.9)	1.8	(0.0, 4.3)	5.8	(2.0, 9.7)	7.6	(3.8, 11.5)
	Mountainous area	222	9.1*	(3.3, 14.9)	4.2*	(0.5, 7.9)	10.8	(6.6, 15.0)	15.1*	(10.7, 19.4)	20.3	(8.6, 31.9)
	East Coast area	211	7.4*	(4.4, 10.3)	6.4*	(4.7, 8.1)	8.0	(2.6, 13.4)	10.9	(2.8, 18.9)	10.5	(4.0, 17.0)
	Peng-Hu islands	205	12.0	(8.3, 15.7)	10.8	(7.7, 13.9)	5.9	(2.1, 9.8)	11.2	(7.6, 14.8)	7.1	(3.9, 10.2)
	Metropolitan cities	193	16.5	(14.2, 18.8)	9.5	(7.8, 11.2)	4.1	(0.0, 9.2)	7.5	(3.0, 11.9)	10.0	(4.2, 15.8)
	Provincial cities and class I townships	185	13.9	(4.4, 23.4)	10.7	(0.8, 20.5)	7.3	(4.0, 10.5)	10.7	(7.4, 13.9)	6.1	(4.5, 7.6)
	Class II townships	209	13.2	(6.0, 20.4)	9.4	(3.1, 15.8)	11.6	(2.5, 20.6)	11.9	(8.9, 14.9)	6.9	(4.7, 9.2)

* Significantly different from metropolitan cities at $\alpha=0.05$ level

$^{+}$ Significantly different from females at $\alpha=0.05$ level

Table 6. The Mean, Standard Error of Intakes of Total Energy, Fat, Saturated Fatty acid, Polyunsaturated Fatty Acid., Percent Fat and P/S Ratio of Adults between 19 and 64 Years Old for Each Stratum. All the Values Have Been Weighed by Sampling Weights.

	Geographical locations	N	Energy (KCAL)		Fat (g)		SFA[1] (g)		PUFA[2] (g)		%Fat[3]		P/S ratio		Keys Score	
			Mean	s.e	Mean	s.e.	Mean	s.e.	Mean	s.e.	Mean	s.e.	Mean	s.e.	Mean	s.e.
Males	Hakka area	141	2371^{+}	106	86.2^{+}	4.1	27.1^{+}	1.3	22.7^{+}	1.2	28.9^{*+}	0.6	1.01^{+}	0.05	14.70^{+}	0.58
	Mountainous area	148	2183^{+}	64	69.7^{+}	2.2	21.7^{+}	0.8	20.7^{+}	1.0	26.2	1.1	1.15^{*+}	0.03	12.76^{+}	1.14
	East Coast area	149	2502^{+}	245	77.9	5.7	30.1^{+}	3.1	23.2	1.8	31.0^{+}	1.6	1.07^{+}	0.04	13.76	0.73
	Peng-Hu islands	133	2134^{+}	111	62.6	6.1	18.5^{+}	1.4	27.3	6.1	25.6^{+}	1.0	1.52*	0.11	7.62*	1.51
	Metropolitan cities	149	2296^{+}	210	70.2	10.3	25.2	4.7	21.5	3.1	26.4^{+}	1.2	1.05^{+}	0.03	13.98	0.71
	Provincial cities and class I townships	132	2174^{+}	128	82.9^{+}	12.3	26.3^{+}	4.1	21.5	2.0	28.8	0.5	0.98^{+}	0.03	13.94	0.71
	Class II townships	145	2450^{+}	99	90.0^{+}	7.3	28.9^{+}	3.0	23.6^{+}	1.4	29.7^{*+}	1.1	1.05^{+}	0.09	13.85^{+}	0.90
Females	Hakka area	157	1551	80	60.4	4.9	18.1	1.8	17.5	1.5	31.4	0.8	1.27	0.15	14.16	1.37
	Mountainous area	168	1576	143	61.3	5.2	17.6	1.0	20.8	3.4	30.7	0.6	1.41	0.05	9.32*	0.49
	East Coast area	159	1553	82	56.1	3.1	17.2	1.5	17.5	0.9	29.8	1.5	1.36	0.12	11.85	0.69
	Peng-Hu islands	170	1588	104	55.4	5.3	15.3	1.2	21.6	2.8	28.3	0.8	1.67*	0.10	6.50*	0.98
	Metropolitan cities	155	1781	142	63.3	5.6	19.9	1.6	20.0	2.6	30.7	1.2	1.23	0.08	12.97	1.14
	Provincial cities and class I townships	150	1534	101	53.8	7.2	16.5	2.6	17.1	2.3	29.0	2.6	1.25	0.05	12.28	1.04
	Class II townships	171	1629	110	66.4	6.3	19.8	2.3	19.3	1.6	33.0	1.2	1.27	0.12	12.67	0.86

1. Saturated fatty acid
2. Polyunsaturated fatty acid
3. Percent fat as energy

* Significantly different from metropolitan cities at α=0.05 level

$^{+}$ Significantly different from females at α=0.05 level

Table 7. The Association Between Each Dietary Factors and Blood Cholesterol, LDL-C, HCL-C and Triglycerides Controlling for Age and BMI.

Sex	Dietary Factors	Cholesterol Coefficient (s.e)		LDL-C Coefficient (s.e)		HDL-C Coefficient (s.e.)		TG Coefficient (s.e)	
Males	Dietary cholesterol (mg/1000kcal)	0.01	(0.01)	0.02+	(0.01)	0.01+	(0.00)	-0.08*	(0.03)
	Keys score	0.22*	(0.08)	0.25*	(0.08)	0.03	(0.04)	-0.34	(0.27)
	Fat intake (% of calories)	0.05	(0.09)	0.14+	(0.08)	-0.02	(0.04)	-0.37	(0.27)
	SFA (% of calories)	0.37	(0.24)	0.56*	(0.23)	-0.02	(0.11)	-0.83	(0.78)
	PUFA (% of calories)	-0.31	(0.25)	0.10	(0.24)	-0.09	(0.11)	-1.59*	(0.79)
	Alcohol (g/day)	0.02	(0.02)	-0.06*	(0.02)	0.02*	(0.01)	0.29*	(0.06)
Females	Dietary cholesterol (mg/1000kcal)	0.00	(0.01)	0.00	(0.01)	-0.00	(0.00)	0.00	(0.02)
	Keys score	0.11	(0.07)	0.07	(0.06)	0.02	(0.03)	0.09	(0.16)
	Fat intake (% of calories)	-0.12	(0.08)	-0.09	(0.07)	-0.04	(0.04)	0.04	(0.18)
	SFA (% of calories)	-0.06	(0.23)	-0.04	(0.21)	-0.05	(0.11)	0.15	(0.52)
	PUFA (% of calories)	-0.49*	(0.19)	-0.33+	(0.17)	-0.11	(0.09)	-0.26	(0.44)
	Alcohol (g/day)	-0.05	(0.04)	-0.14*	(0.04)	0.06*	(0.01)	0.15+	(0.09)

* Significantly different from zero at α=0.05.
\+ Significantly different from zero at α=0.10.

the lipid profile of women became worse than that of males after the age of 65 years. However, females had favorable distribution of cholesterol sub-fractions as indicated by higher HDL-C and lower ratio of total cholesterol to HDL-C than males in all ages.

The average total serum cholesterol values and the prevalence of hypercholesterolemia in males and females in all age groups were higher than those of Africans, similar to those in Pakistan or the Philippines, but a lot lower than Americans or Europeans, especially people in Finland (14). Although, the evolutional changes in lipid status of many these countries are not clear, Taiwanese cholesterol level was lower than that of American at the same period of time as shown by NHANES III (11). The average HDL-C of people in Taiwan was higher than that in the USA or in Germany for all age groups. The average triglyceride values of both males and females in all age groups were lower than those of Americans measured between 1988 and 1991 (NHANES III) (11). The average triglyceride values of males were lower than that of German obtained by the PROCAM study (1). The prevalence was about the same as that in Germany (1). Females had higher mean values and higher prevalence of hypertriglyceridemia than German females. The mean triglyceride values of males and females were higher than those surveyed in the past (6-7) and those of some areas in Mainland China (2, 23, 25). Whether the high average triglycerides value is related to obesity and insulin resistance is worth of further investigation (18).

People in Singapore, including ethnic Chinese, Malays and Indians, had higher level of cholesterol than people in Taiwan (9). The mean values of total cholesterol in Singapore females aged 38 ± 12 years was 5.4 ± 1.1 mmol/l, 5.7 ± 1.1 mmol/l and 5.3 ± 1.0 mmol/l for ethnic Chinese, Malays and Indians, respectively. Similar patterns were found in males whose average cholesterol was above 5.5 mmol/l for all ethnic groups (9).

The average cholesterol values were close to those reported in studies of other areas in Taiwan (17), but they were higher than those of some areas in Mainland China. For example, the PRC-USA study, which was conducted between 1983 and 1984, reported the mean values of total cholesterol was between 4.25 and 4.66 mmol/l for men and between 4.09 and 4.99 mmol/l for women (26). The highest mean values for both men and women were observed in urban Guangzhou (26).

Results on the relationships between dietary intakes and blood lipids showed that Keys score, which accounts for types of fat and cholesterol intakes, was positively related to blood cholesterol level and LDL-C in men. In women, the polyunsaturated fatty acids, one component of the Keys equation was negatively associated with blood cholesterol level. These findings are consistent with earlier works of Ancel Key's and others (12), demonstrating the effects of a single or several dietary components. In addition, alcohol intake has been associated with levels and subtypes of HDL-C (15). The relation between alcohol intake and LDL-C has been unclear and affected by Apo E genotypes (8). Our data showed positive associations between alcohol intakes and HDL-C and triglycerides, and a negative association with LDL-C both in men and women. The extent of these relationships may be even greater, since measurement errors associated with 24-hr-recall data are likely to attenuate the magnitude of the dietary effects. The relationships between life styles, environments and blood lipid profiles should be taken into consideration in developing prevention strategy for dyslipidemia, particularly when regional differences in lipid profiles are in part explained by these factors in Taiwan.

Each geographical area in this study had its own uniqueness in its blood lipid profile, which were summarized as follows.

Metropolitan Cities

These cities were the most urbanized areas in Taiwan. The average cholesterol values and prevalence of hypercholesterolemia in males and females in these cities were the highest among all strata in Taiwan. Nevertheless, the females had very good quality of cholesterol; in other words, the ratio of total serum cholesterol to HDL-C was among the lowest. Males in these cities had relatively high values of the ratio of total serum cholesterol to HDL-C. The prevalence of hypertriglyceridemia in females was significantly lower than that of males. The prevalence of hypertriglyceridemia in males was a little lower than that in mountainous areas and east coast. The prevalence of dyslipidemia in metropolitan females was close to the lower end and that of metropolitan males was close to the higher end of the prevalence range in Taiwan.

Hakka Areas

The mortality rate of coronary heart diseases in these areas was considered to be slightly high in Taiwan. This survey revealed that the prevalence in hypercholesterolemia was fairly high in males (only lower than that in metropolitan cities). But the quality of cholesterol (ratio of total serum cholesterol to HDL-C) was at the lower end of all the strata. The average triglyceride values and the prevalence of hypertriglyceridemia ranked towards to the lower end of all strata.

Provincial Cities and Urbanization Class I and Class II Townships

The mean values of total serum cholesterol, HDL-C, the ratio of cholesterol to HDL-C and prevalence of dyslipidemia in males of this area were medium comparing to those of the other geographical areas. The prevalence of hypertriglyceridemia was close to lower end in Taiwan, especially in women of these areas.

Mountainous Areas

The average values of total cholesterol and prevalence of hypercholesterolemia in males were the lowest among the 7 strata. Yet, the HDL-C was low and the ratio of total serum cholesterol to HDL-C was high, indicating an unfavorable cholesterol distribution in lipoprotein sub-fractions. This was associated with the high values of triglycerides and high prevalence of hypertriglyceridemia in mountainous areas, possibly reflecting a phenomenon of metabolic disorder resulting from changes of life styles.

East Coast Area

Proportion of aboriginees is high in East Coast areas than in other non-mountainous areas. All the values and patterns were similar to (a little better than) those of the mountainous area. Situations in females were better than those in the mountainous areas.

Peng-Hu Islands

The blood lipids of males were very different from females in this area. Males had the lowest cholesterol values among all the strata, while females had relatively higher cholesterol values than other strata. The prevalence of hypercholesterolemia in females was close to that of the metropolitan cities, while that in males was the lowest among all strata. The prevalence of low HDL-C was at lower ends of all strata in both males and females. The proportion of high ratio of total cholesterol to HDL-C of males was the lowest among all strata. However, that of the females was the higher end. The prevalence of hypertriglyceridemia in males was the lowest among the 7 strata, while that in females was the slightly lower than those in the metropolitan cities.

The blood lipid profile of people in different areas of Taiwan seemed to correspond to their degree of urbanization and life styles. The high mean value of triglycerides and prevalence of hypertriglyceridemia in males of the mountainous area were consistent with their high BMI values and alcohol intakes. Values of triglycerides have also been associated with obesity and alcoholism in Singapore with multi-ethnic populations (9). The prevalence of hypercholesterolemia, high LDL-C, low HDL-C, high ratio of total cholesterol to HDL-C, and hypertriglyceridemia were relatively high in metropolitan cities, demonstrating the impact of urbanization and dietary patterns.

Overall, the blood lipid profiles of people in Taiwan were better than those of the western countries. However, the magnitude of the dyslipidemia prevalence was greater than those of the past surveys or those of people in Mainland China. Regional differences in lipid profiles can be in part explained by dietary and life-style factors. It implied the economic growth, variations of life-styles in various regions had impacts on blood lipids, important risk factors of coronary heart disease. Therefore, primary prevention with public health measures focusing on life-styles and diets have to be implemented in order to prevent the epidemic of coronary heart diseases.

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