J Atheroscler Thromb, 2018; 25: 606-620.
http://doi.org/10.5551/jat.42531

Original Article

# Associations between Socioeconomic Status and the Prevalence and Treatment of Hypercholesterolemia in a General Japanese Population: NIPPON DATA2010

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***Aim*: To investigate associations between socioeconomic status (SES) and the prevalence and treatment status of hypercholesterolemia in a general Japanese population.**

***Methods*: In 2010, we established a cohort study of 2417 adults (age 20−91 yr) from 300 randomly selected areas across Japan who participated in the National Health and Nutrition Survey of Japan. We cross-sectionally examined an association between SES and (1) prevalence of hypercholesterolemia in 2417 participants (999 men and 1418 women) and (2) not receiving medication for hypercholesterolemia in 654 participants (215 men and 439 women). SES included employment status, marital status, length of education, and household expenditures. Hypercholesterolemia was defined as a total serum cholesterol level of ≥6.21 mmol/L (240 mg/dL) or the use of lipid-lowering medications.**

***Results*: The overall prevalence of hypercholesterolemia was 21.5% in men and 31.0% in women. In men, the lowest quintile of household expenditures was associated with a higher prevalence of hypercholesterolemia (28.3%) compared with the upper 4 quintiles (19.9%) (multivariable-adjusted odds ratio 1.66; 95% confidence interval [CI] 1.16−2.38). Among participants with hypercholesterolemia, 55.4% of men and 55.1% of women were not receiving medication. Unmarried men were more likely to be untreated (75.0%) than married men (50.9%) (multivariable-adjusted odds ratio 2.53; 95%CI 1.05−6.08). SES had no significant effects in women.**

***Conclusion*: In a general population of Japanese men, low household expenditures were associated with a higher prevalence of hypercholesterolemia, and unmarried men with hypercholesterolemia were less likely to receive medication.**

**Key words:** Hypercholesterolemia, Socioeconomic status, Treatment, Risk factor, Japan



## Introduction

Cardiovascular disease (CVD) is one of the leading causes of premature death in Japan as well as other regions of the world[1, 2]. Hypercholesterolemia is one of potential key risk factors for fatal and nonfatal CVD[2-7]. In Japan, however, cholesterol levels have increased significantly since the late 1960s and have reached a similar level as that in Western countries[2, 8-10]. Effective CVD prevention requires a strategy based on the

reasons why cholesterol levels remain high in Japan.

A number of epidemiological studies have suggested that indicators of socioeconomic status (SES) such as education, household income or expenditures, marital status, and employment status were associated with cardiovascular risk factors including hypercholesterolemia[11-15]. Some studies also reported the heterogeneous effects of SES on serum lipid levels between men and women[16, 17]. Furthermore, it has been shown that low SES was associated with limited access to health-care services and preventive care[18-20]. However, there is limited evidence regarding separate associations between SES and the prevalence or treatment of hypercholesterolemia in men and women, particularly in Japan.

## Aim

The objective of the present analysis was to examine the associations between household expenditures, employment status, length of education, and marital status and the prevalence and treatment of hypercholesterolemia in a cross-sectional analysis of a representative, general population of Japanese men and women.

## Methods

### Study Population

In 2010, a prospective cohort study on CVDs—National Integrated Project for Prospective Observation of Non-communicable Disease And its Trends in the Aged (NIPPON DATA2010)—was established[21-23]. This study was performed with the National Health and Nutrition Survey of Japan (NHNS) in November 2010 (NHNS2010) and the Comprehensive Survey of Living Conditions (CSLC) in June 2010 (CSLC2010), both of which are conducted by the Ministry of Health, Labour and Welfare of Japan. Details regarding NHNS2010 and CSLC2010 have been described elsewhere[24-26].

In November 2010, 8815 residents (age ≥1 yr) from 300 randomly selected districts across Japan participated in the NHNS2010 dietary survey. Among 7229 participants ≥20 yr, 3873 participants (1598 men and 2275 women) had a blood test, and 2898 (1239 men and 1659 women) agreed to participate in the baseline NIPPON DATA2010 survey, which also included electrocardiographic analysis, urinalysis, and a questionnaire regarding CVD. Trained interviewers obtained informed consent before enrollment. Of these 2898 participants, 7 participants were excluded because data from NHNS2010 or CSLC2010 could not be merged with baseline NIPPON DATA2010 data, and 276 participants were excluded because of missing data on SES (employment status, marital status, length of education, and/or equivalent household expenditure). One hundred ninety-eight participants with a history of CVD—which was defined as stroke, myocardial infarction, or angina pectoris—were also excluded. The remaining 2417 participants were included in the present study. This study consisted of two kinds of cross-sectional analyses that used the baseline NIPPON DATA2010 survey. Analysis 1 included all 2417 participants (999 men and 1418 women) to assess the prevalence of hypercholesterolemia. Analysis 2 included 654 participants with hypercholesterolemia (215 men and 439 women) to assess the lack of hypercholesterolemia treatment. We define treatment for hypercholesterolemia as use of lipid-lowering medication(s). Written informed consent was obtained from all participants, and the Institutional Review Board of Shiga University of Medical Science (No. 22-29, 2010) approved this study.

### Lipid Measurement and Definition of Hypercholesterolemia

Casual blood samples were obtained for NHNS 2010. Serum was separated and centrifuged soon after blood coagulation, and plasma samples were collected in siliconized tubes containing sodium fluoride and shipped to a central laboratory (SRL, Tokyo, Japan) for analysis. Serum total cholesterol was measured by the cholesterol dehydrogenase−ultraviolet (UV) method and standardized by the Centers for Disease Control and Prevention/US Collaborating Center for Reference Method Laboratory Network Research in Blood Lipids[27]. Triglycerides were measured using enzyme methods, and high-density lipoprotein (HDL) cholesterol and low-density lipoprotein (LDL) cholesterol were measured using direct methods (Cholestest®LDL Sekisui Medical). Information on the use of medications was collected using a self-administered questionnaire. Hypercholesterolemia was defined as total cholesterol level ≥6.21 mmol/L (240 mg/dL)[28] and/or the use of antihypercholesterolemic agents. Information on the use of lipid-lowering medications was obtained using a questionnaire and confirmed by trained staff. Untreated hypercholesterolemia was defined as not receiving lipid-lowering medications.

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Received: September 11, 2017
Accepted for publication: November 9, 2017

**Table 1.** Characteristics of all participants and participants with hypercholesterolemia by sex, Japan, 2010

| | Men | | Women | |
|---|---|---|---|---|
| | Total ($n$ = 999) | Hypercholesterolemia ($n$ = 215) | Total ($n$ = 1418) | Hypercholesterolemia ($n$ = 439) |
| Age, years | 59.1 (15.4) | 60.7 (13.4) | 57.2 (15.8) | 64.7 (10.9) |
| Unemployed | 330 (33.0) | 76 (35.3) | 807 (56.9) | 285 (64.9) |
| Unmarried | 186 (18.6) | 40 (18.6) | 368 (26.0) | 127 (28.9) |
| Length of education < 13 years | 655 (65.6) | 143 (66.5) | 973 (68.6) | 344 (78.4) |
| Lowest quintile of equivalent household expenditure | 198 (19.9) | 56 (26.0) | 279 (19.7) | 86 (19.6) |
| Body mass index, kg/m$^2$ | 23.8 (3.2) | 24.3 (3.4) | 22.6 (3.5) | 23.4 (3.4) |
| Systolic BP, mmHg | 135.8 (17.8) | 140 (18.6) | 129.1 (20.0) | 136.2 (19.4) |
| Diastolic BP, mmHg | 82.5 (10.7) | 83.9 (10.8) | 77.1 (10.8) | 79.6 (10.4) |
| Total cholesterol, mmol/L | 5.27 (0.87) | 6.06 (1.06) | 5.40 (0.92) | 6.13 (1.00) |
| HDL cholesterol, mmol/L | 1.47 (0.39) | 1.53 (0.45) | 1.72 (0.40) | 1.76 (0.45) |
| LDL cholesterol, mmol/L | 3.09 (0.76) | 3.64 (0.95) | 3.09 (0.81) | 3.64 (0.92) |
| Triglycerides, mmol/L [†] | 1.45 (1.00−2.15) | 1.66 (1.17−2.62) | 1.10 (0.75−1.59) | 1.37 (0.96−1.91) |
| Hypertensive [§] | 554 (55.5) | 138 (64.2) | 567 (40.0) | 247 (56.3) |
| Diabetes mellitus [‡] | 125 (12.5) | 43 (20.0) | 115 (8.1) | 58 (13.2) |
| Smoking | | | | |
| Ex-smoker | 408 (41.1) | 95 (44.4) | 123 (8.7) | 34 (7.8) |
| Current smoker | 292 (29.4) | 62 (29.0) | 102 (7.2) | 22 (5.0) |
| Regular exercise [*] | 370 (37.2) | 91 (42.5) | 443 (31.3) | 169 (38.6) |
| Alcohol consumption, g/week [¶] | 63.4 (0−241.9) | 51.8 (0−241.9) | 0 (0−17.3) | 0 (0−5.8) |

Abbreviations: BP, blood pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein. Data are shown as mean (standard deviation), median (interquartile range), or n (%).
[†] Triglycerides are shown as the median and interquartile range.
[§] Defined as participants who met 1 or more of the following criteria: 1) systolic BP ≥ 140 mm Hg and/or diastolic BP ≥ 90 mm Hg; or 2) receiving antihypertensive medication.
[‡] Defined as participants who met 1 or more of the following criteria: 1) fasting plasma glucose level ≥ 126 mg/dL (≥ 7.0 mmol/L); or 2) nonfasting plasma glucose level ≥ 200 mg/dL (≥ 11.1 mmol/L); 3) hemoglobin A1c ≥ 6.5%; or 4) receiving antidiabetic medication.
[*] Defined as participants who engaged in ≥ 30 minutes of exercise for ≥ 2 days/week for > 1 year.
[¶] Alcohol consumption is shown as the median and interquartile range.

**Socioeconomic Status**

Information on SES was collected using self-administered questionnaires for NHNS2010 (employment status), CSLC2010 (monthly household expenditures in May 2010; i.e., the month before CSLC 2010), and NIPPON DATA2010 (length of education, marital status). Equivalent household expenditures were calculated as the household expenditure divided by the square root of the number of family members. SES was defined as follows: (1) employment status (unemployed or employed [including self-employed]); (2) marital status (married, unmarried [including never married, divorced, and widowed]); (3) length of education (< 13 yr [primary school and/or high school] or ≥ 13 yr); and (4) equivalent household expenditure (upper 4 quintiles or the lowest quintile [< ¥82,000 JPY (approximately $750/month]).

**Other Risk Factors**

After a minimum of 5 min of rest in a seated position, blood pressure (BP) was measured twice with an interval of ≥ 1 min by trained survey staff using a standard mercury sphygmomanometer with an appropriately sized cuff on the right arm. The mean of the two measurements was used in further analyses. Hypertension was defined as systolic BP ≥ 140 mm Hg and/or diastolic BP ≥ 90 mm Hg or the use of antihypertensive medications. Plasma glucose was measured using the hexokinase UV method, and hemoglobin A1c (HbA1c) was measured using a latex agglutination inhibition assay according to the standardized method of the Japan Diabetes Society (JDS). HbA1c was converted to the National Glycohemoglobin Standardization Program (NGSP) value using the following formula: HbA1c (NGSP) (%) = 1.02 × HbA1c (JDS) (%) + 0.25. A blood sample was defined as a fasting blood sample if it was obtained after ≥ 8 h of fasting. Participants were classified as diabetic if they met one of the following criteria[29]: (1) fasting plasma glucose level ≥ 126 mg/dL (≥ 7.0 mmol/L); (2) nonfasting plasma glucose level

**Table 2.** Association between socioeconomic status and hypercholesterolemia prevalence in 999 men

| Socioeconomic status | N of participants | Hypercholesterolemia, n (%) | Odds ratio (95% confidence interval) | |
|---|---|---|---|---|
| | | | Model 1 | Model 2 |
| Employment status | | | | |
| Employed | 669 | 139 (20.8) | Reference | Reference |
| Unemployed | 330 | 76 (23.0) | 0.96 (0.66−1.40) | 0.97 (0.67−1.41) |
| Marital status | | | | |
| Married | 813 | 175 (21.5) | Reference | Reference |
| Unmarried | 186 | 40 (21.5) | 1.09 (0.73−1.62) | 1.05 (0.70−1.56) |
| Length of education | | | | |
| ≥13 years | 344 | 72 (20.9) | Reference | Reference |
| <13 years | 655 | 143 (21.8) | 0.97 (0.69−1.35) | 0.94 (0.67−1.32) |
| Equivalent household expenditure | | | | |
| Upper 4 quintiles | 801 | 159 (19.9) | Reference | Reference |
| Lowest quintile | 198 | 56 (28.3) | 1.60 (1.12−2.29) | 1.66 (1.16−2.38) |

Model 1 was adjusted for age. Model 2 was adjusted like Model 1, in addition to adjustments for history of diabetes mellitus, hypertension, and type of house (own or rent; this was only included in the analysis of household expenditures).

≥200 mg/dL (≥11.1 mmol/L); (3) HbA1c ≥6.5%; or (4) currently receiving antidiabetic medications.

**Statistical Analysis**

The characteristics of the study participants are presented as the mean and standard deviation for continuous variables and as the number and percentage for categorical variables. The association between SES and each outcome was assessed using age-adjusted logistic regression (Model 1) and multivariable-adjusted logistic regression (Model 2). The multivariable-adjusted model included age, diabetes mellitus, hypertension, and type of house (owned or rented; this was only included in the analyses of equivalent household expenditures). The type of house was determined using the CSLC2010 questionnaire and used as a covariate because expenditures included household rent but not mortgages. The results of the logistic regression analyses are reported as odds ratios (ORs) with corresponding 95% confidence intervals (95%CIs). The associations between SES and each outcome in the subgroups (defined by age or menopausal status) were compared by adding an interaction term to the statistical model. $P<0.05$ was considered statistically significant. All statistical analyses were performed using SAS (version 9.4 for Windows; SAS Institute Inc., Cary, NC, USA).

## Results

**Participant Characteristics**

The characteristics of the participants that were included in each cross-sectional analysis are shown by sex in **Table 1**. Among 999 men and 1418 women, 330 men (33.0%) and 807 women (56.9%) were unemployed, 186 men (18.6%) and 368 women (26.0%) were unmarried, 655 men (65.6%) and 973 women (68.6%) had <13 yr of education, and 198 men (19.8%) and 279 women (19.7%) were in the lowest quintile of equivalent household expenditures. Among 215 men (21.5%) and 439 women (31.0%) with hypercholesterolemia (Analysis 2), 76 men (35.3%) and 285 women (64.9%) were unemployed, 40 men (18.6%) and 127 women (28.9%) were unmarried, 143 men (66.5%) and 344 women (78.4%) had <13 yr of education, and 56 men (26.0%) and 86 women (19.6%) were in the lowest quintile of equivalent household expenditures. The characteristics of the participants with hypercholesterolemia are also shown by sex and SES in **Supplementary Tables 1** and **2**.

**Associations between SES and Hypercholesterolemia Prevalence in Men**

**Table 2** shows the associations between SES and hypercholesterolemia prevalence in men. The lowest quintile of household expenditures was associated with more prevalent hypercholesterolemia (28.3%) compared with higher quintiles (19.9%). The OR of the lowest quintile versus the higher quintiles was 1.66 (95%CI 1.16−2.38) after adjusting for confounding factors. This association remained significant even after further adjusting for other items related to SES: the OR of the lowest quintile versus the higher quintiles was 1.70 (95%CI 1.18−2.44). There was a trend toward a larger effect of household expenditures on hypercholesterolemia prevalence in participants <65 yr than in those ≥65 yr, but the difference was not statistically sig-

**Table 3.** Association between socioeconomic status and hypercholesterolemia prevalence in 1418 women

| Socioeconomic status | N of participants | Hypercholesterolemia, n (%) | Odds ratios (95% confidence intervals) | |
|---|---|---|---|---|
| | | | Model 1 | Model 2 |
| Employment status | | | | |
| Employed | 611 | 154 (25.2) | Reference | Reference |
| Unemployed | 807 | 285 (35.3) | 0.85 (0.65−1.12) | 0.85 (0.65−1.12) |
| Marital status | | | | |
| Married | 1050 | 312 (29.7) | Reference | Reference |
| Unmarried | 368 | 127 (34.5) | 1.02 (0.78−1.34) | 1.00 (0.76−1.31) |
| Length of education | | | | |
| ≥13 years | 445 | 95 (21.4) | Reference | Reference |
| <13 years | 973 | 344 (35.4) | 1.03 (0.76−1.39) | 1.01 (0.74−1.36) |
| Equivalent household expenditure | | | | |
| Upper 4 quintiles | 1139 | 353 (31.0) | Reference | Reference |
| Lowest quintile | 279 | 86 (30.8) | 0.84 (0.62−1.13) | 0.82 (0.61−1.11) |

Model 1 was adjusted for age. Model 2 was adjusted like Model 1, in addition to adjustments for history of diabetes mellitus, hypertension, and type of house (own or rent; this was only included in the analysis of household expenditures).

nificant (*P* heterogeneity = 0.06) (**Supplementary Table 3**). Other SES variables were not clearly associated with hypercholesterolemia prevalence. Similar findings were obtained when different definitions for hypercholesterolemia were used (LDL-C >4.14 mmol/L and non-HDL cholesterol [NHDL-C] >4.91 mmol/L) (**Supplementary Table 4**).

### Associations between SES and Hypercholesterolemia Prevalence in Women

**Table 3** shows the associations between SES and hypercholesterolemia prevalence in women. Employment status, marital status, length of education, and household expenditures were not clearly associated with hypercholesterolemia. There were no significant differences in the associations between SES and hypercholesterolemia in the subgroups defined by age, except for length of education (*P* heterogeneity = 0.01) (**Supplementary Table 3**). There was also no heterogeneity in the effects of SES on hypercholesterolemia between premenopausal and postmenopausal women (*P* heterogeneity >0.1) (**Supplementary Table 5**).

### Associations between SES and not Receiving Hypercholesterolemia Treatment in Men

**Table 4** shows the associations between SES and untreated hypercholesterolemia in men. Unmarried men were more likely to be untreated (75.0%) than married men (50.9%). The OR of unmarried versus married men was 2.53 (95%CI 1.05−6.08) after adjusting for confounding factors. There were no significant differences in the effects of marital status on untreated hypercholesterolemia between participants <65 and ≥65 yr (*P* heterogeneity = 0.22) (**Supplementary Table 7**). Other SES variables were not clearly associated with untreated hypercholesterolemia. Similar findings were obtained when different definitions of hypercholesterolemia were used (LDL-C >4.14 mmol/L and NHDL-C >4.91 mmol/L) (**Supplementary Table 6**).

### Associations between SES and not Receiving Hypercholesterolemia Treatment in Women

**Table 5** shows the associations between SES and untreated hypercholesterolemia in women. Employment status, marital status, length of education, and household expenditures were not clearly associated with untreated hypercholesterolemia. There were heterogeneous associations between marital status with untreated hypercholesterolemia in women <65 yr (OR 4.63; 95% CI 1.30−16.42) and women ≥65 yr (OR 0.90; 95%CI 0.50−1.61) (*P* heterogeneity = 0.01). There were no other significant differences in the associations between SES and untreated hypercholesterolemia in the subgroups defined by age (*P* heterogeneity >0.52) (**Supplementary Table 7**). There was no heterogeneity in the effects of SES on untreated hypercholesterolemia between premenopausal and postmenopausal women (*P* heterogeneity >0.9) (**Supplementary Table 5**).

## Discussion

In the present analysis of a nationwide survey of a general Japanese population, male participants in the lowest quintile of household expenditures had a higher prevalence of hypercholesterolemia compared with men in the upper quintiles. Unmarried men were less likely

**Table 4.** Association between socioeconomic status and untreated hypercholesterolemia in 215 men

| Socioeconomic status | N of participants | Untreated, n (%) | Odds ratios (95% confidence intervals) | |
|---|---|---|---|---|
| | | | Model 1 | Model 2 |
| Employment status | | | | |
| Employed | 139 | 86 (61.9) | Reference | Reference |
| Unemployed | 76 | 33 (43.4) | 1.31 (0.64−2.66) | 1.34 (0.65−2.77) |
| Marital status | | | | |
| Married | 175 | 89 (50.9) | Reference | Reference |
| Unmarried | 40 | 30 (75.0) | 2.13 (0.90−5.07) | 2.53 (1.05−6.08) |
| Length of education | | | | |
| ≥13 years | 72 | 47 (65.3) | Reference | Reference |
| <13 years | 143 | 72 (50.4) | 0.83 (0.43−1.59) | 0.94 (0.48−1.87) |
| Equivalent household expenditure | | | | |
| Upper 4 quintiles | 159 | 89 (56.0) | Reference | Reference |
| Lowest quintile | 56 | 30 (53.6) | 0.66 (0.33−1.32) | 0.67 (0.33−1.36) |

Model 1 was adjusted for age. Model 2 was adjusted like Model 1, in addition to adjustments for history of diabetes mellitus, hypertension, and type of house (own or rent; this was only included in the analysis of household expenditures).

to receive "drug" treatment for hypercholesterolemia compared with married men. These associations remained significant even after controlling for confounding factors such as age, diabetes mellitus, and hypertension. In contrast, SES was not clearly associated with hypercholesterolemia prevalence or not receiving treatment for hypercholesterolemia in women. These findings would provide important scientific insights to health policy-makers who underscore attenuation of inequality in health status as well as that in SES.

**SES and Hypercholesterolemia Prevalence**

To the best of our knowledge, no previous epidemiologic studies have reported inverse associations between household expenditures and hypercholesterolemia, but an observational study in Greece reported higher hypercholesterolemia prevalence in men with less education[30]. Possible mechanisms underlying the link between low SES and hypercholesterolemia may involve lifestyle choices. In fact, it has been reported that people from socioeconomically disadvantaged backgrounds are less likely to choose food products that are low in saturated fat[31, 32]. Another possible mechanism may involve the limited utilization of health services among people with lower SES. For example, employees of small companies have been shown to be less likely to participate in health checkups than were the employees of large companies[33]. On the basis of the findings of the present analysis and previous epidemiologic studies, men with low SES are more likely to have hypercholesterolemia; in contrast, there were no significant associations between SES and hypercholesterolemia in women. The observed sex difference was consistent with previous reports from Japanese populations, which indicated that disadvantage in health status associated with low SES may be more evident in men than in women[34, 35]. The mechanisms underlying heterogeneous effects of SES between men and women may involve differences in lifestyle, occupational status (including type of occupation), access to health care, and attitude toward health information[35]. Interestingly, the sex difference observed in our study differs from what was found in studies conducted in Europe or the United States, where women had a stronger association than in men. However, SES and health outcome could have a complex relationship, and we agree with Kagamimori and the colleagues in their notion that "SES must be interpreted within the economic, social, demographic and cultural contexts of a specific country"[34].

**SES and Hypercholesterolemia Treatment**

To the best of our knowledge, this is the first study to examine the association between marital status and hypercholesterolemia treatment status in a general population. In the present analysis, married men with hypercholesterolemia were more likely to be treated than unmarried men, but such associations were only observed in women <65 yr. These findings are in line with a previous observational study that reported that, with regard to choosing between healthy behaviors and/or compliance with medical treatment, married men are more likely to be affected by their partners than were married women[36, 37]. It has also been reported that never-married Japanese men have a less healthy lifestyle and subsequently higher levels of cardiovascu-

**Table 5.** Association between socioeconomic status and untreated hypercholesterolemia in 439 women

| Socioeconomic status | N of participants | Untreated, n (%) | Odds ratios (95% confidence intervals) | |
|---|---|---|---|---|
| | | | Model 1 | Model 2 |
| Employment status | | | | |
| Employed | 154 | 98 (63.6) | Reference | Reference |
| Unemployed | 285 | 144 (50.5) | 1.24 (0.77−2.00) | 1.24 (0.76−2.00) |
| Marital status | | | | |
| Married | 312 | 176 (56.4) | Reference | Reference |
| Unmarried | 127 | 66 (52.0) | 1.24 (0.77−1.99) | 1.35 (0.83−2.20) |
| Length of education | | | | |
| ≥ 13 years | 95 | 70 (73.6) | Reference | Reference |
| < 13 years | 344 | 172 (50.0) | 0.61 (0.35−1.07) | 0.66 (0.37−1.17) |
| Equivalent household expenditure | | | | |
| Upper 4 quintiles | 353 | 205 (58.1) | Reference | Reference |
| Lowest quintile | 86 | 37 (43.0) | 0.66 (0.39−1.12) | 0.66 (0.39−1.13) |

Model 1 was adjusted for age. Model 2 was adjusted like Model 1, in addition to adjustments for history of diabetes mellitus, hypertension, and type of house (own or rent; this was only included in the analysis of household expenditures).

lar risk factors than do married men[38]. Regarding other SES items than marital status, an observational study from India reported that patients with hypercholesterolemia who had had a longer length of education were more likely to receive drug treatment[39, 40]. In the present study, however, length of education, employment status, and household expenditures were not clearly associated with untreated hypercholesterolemia. The reason for this discrepancy is not clear, but the lack of associations in this study of a general Japanese population may be because of the universal health insurance coverage system that allows Japanese citizens to access medical care regardless of SES[41].

**Strengths and Limitations**

This is the first study to demonstrate the associations between various SES items with the prevalence of untreated hypercholesterolemia based on a nationwide survey of a Japanese general population. Additionally, we conducted multivariable-adjusted analyses, whereas some preceding reports reported results after adjusting for a limited number of covariates. In the present analysis, some of the results remained significant after adjusting for age, diabetes mellitus, and hypertension, which suggests that other factors may mediate the link between SES and hypercholesterolemia. Further studies are needed to elucidate the mechanisms underlying this link.

The present analysis has several limitations. First, because of the cross-sectional nature of this study, we were unable to determine whether there was a causal relationship between SES and the prevalence or treatment of hypercholesterolemia. The second limitation is reporting bias for SES items (i.e., underreporting of very high status or overreporting of very low status), which could have weakened the association between SES and the prevalence and treatment of hypercholesterolemia. Third, we did not assess whether treatment (i.e.,., use of medication) was translated into an appropriate clinical goal, which can be an important indicator according to a recent report from a multicountry survey[42]. Further study is needed to address this issue. Finally, the findings of the present analysis may not be generalizable to other countries where lifestyle, access to medical care, and medical insurance coverage differ from those found in Japan.

## Conclusion

In a general population of Japanese men, low household expenditures were associated with a higher prevalence of hypercholesterolemia, and unmarried men with hypercholesterolemia were less likely to receive drug treatment. The findings indicate that preventing cardiovascular events require a combination of high-risk and population strategies that focus on socioeconomic as well as traditional risk factors.

## Acknowledgements

This study was supported by Health and Labour Sciences Research Grants from the Ministry of Health, Labour and Welfare, Japan (Comprehensive Research on Life-Style Related Diseases including Cardiovascular Diseases and Diabetes Mellitus [H22-Junkankitou-Seishuu-Sitei-017, H25-Junkankitou-Seishuu-Sitei-022]).

## Conflict of Interest

All authors have disclosed their potential conflict of interest as indicated.

## The NIPPON DATA2010 Research Group

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### References


1) GBD2015 Mortality and Causes of Death Collaborators: Global, regional, and national life expectancy, all-cause mortality, and cause-specific mortality for 249 causes of death, 1980-2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet, 2016; 388: 1459-1544
2) Ueshima H, Sekikawa A, Miura K, Turin TC, Takashima N, Kita Y, Watanabe M, Kadota A, Okuda N, Kadowaki T, Nakamura Y and Okamura T: Cardiovascular disease and risk factors in Asia: a selected review. Circulation, 2008; 118: 2702-2709
3) Di Angelantonio E, Sarwar N, Perry P, Kaptoge S, Ray KK, Thompson A, Wood AM, Lewington S, Sattar N, Packard CJ, Collins R, Thompson SG and Danesh J: Major lipids, apolipoproteins, and risk of vascular disease. JAMA, 2009; 302: 1993-2000
4) Zhang X, Patel A, Horibe H, Wu Z, Barzi F, Rodgers A, MacMahon S and Woodward M: Cholesterol, coronary heart disease, and stroke in the Asia Pacific region. Int J Epidemiol, 2003; 32: 563-572
5) Lewington S, Whitlock G, Clarke R, Sherliker P, Emberson J, Halsey J, Qizilbash N, Peto R and Collins R: Blood cholesterol and vascular mortality by age, sex, and blood pressure: a meta-analysis of individual data from 61 prospective studies with 55,000 vascular deaths. Lancet, 2007; 370: 1829-1839
6) Okamura T, Tanaka H, Miyamatsu N, Hayakawa T, Kadowaki T, Kita Y, Nakamura Y, Okayama A and Ueshima H: The relationship between serum total cholesterol and all-cause or cause-specific mortality in a 17.3-year study of a Japanese cohort. Atherosclerosis, 2007; 190: 216-223
7) Tanabe N, Iso H, Okada K, Nakamura Y, Harada A, Ohashi Y, Ando T and Ueshima H: Serum total and non-high-density lipoprotein cholesterol and the risk prediction of cardiovascular events - the JALS-ECC. Circ J, 2010; 74: 1346-1356
8) Ueshima H: Explanation for the Japanese paradox: prevention of increase in coronary heart disease and reduction in stroke. J Atheroscler Thromb, 2007; 14: 278-286
9) Nguyen HN, Fujiyoshi A, Abbott RD and Miura K: Epidemiology of cardiovascular risk factors in Asian countries. Circ J, 2013; 77: 2851-2859
10) NIPPON DATA80 Research Group: Risk assessment chart

for death from cardiovascular disease based on a 19-year follow-up study of a Japanese representative population. Circ J, 2006; 70: 1249-1255
11) Luepker RV, Rosamond WD, Murphy R, Sprafka JM, Folsom AR, McGovern PG and Blackburn H: Socioeconomic status and coronary heart disease risk factor trends. The Minnesota Heart Survey. Circulation, 1993; 88: 2172-2179
12) Fukuda Y and Hiyoshi A: Associations of household expenditure and marital status with cardiovascular risk factors in Japanese adults: analysis of nationally representative surveys. J Epidemiol, 2013; 23: 21-27
13) Liu K, Cedres LB, Stamler J, Dyer A, Stamler R, Nanas S, Berkson DM, Paul O, Lepper M, Lindberg HA, Marquardt J, Stevens E, Schoenberger JA, Shekelle RB, Collette P, Shekelle S and Garside D: Relationship of education to major risk factors and death from coronary heart disease, cardiovascular diseases and all causes, Findings of three Chicago epidemiologic studies. Circulation, 1982; 66: 1308-1314
14) Stamler R, Shipley M, Elliott P, Dyer A, Sans S and Stamler J: Higher blood pressure in adults with less education. Some explanations from INTERSALT. Hypertension, 1992; 19: 237-241
15) Stamler J, Elliott P, Appel L, Chan Q, Buzzard M, Dennis B, Dyer AR, Elmer P, Greenland P, Jones D, Kesteloot H, Kuller L, Labarthe D, Liu K, Moag-Stahlberg A, Nichaman M, Okayama A, Okuda N, Robertson C, Rodriguez B, Stevens M, Ueshima H, Horn LV and Zhou B: Higher blood pressure in middle-aged American adults with less education-role of multiple dietary factors: the INTERMAP study. J Hum Hypertens, 2003; 17: 655-775
16) Backholer K, Peters SAE, Bots SH, Peeters A, Huxley RR and Woodward M: Sex differences in the relationship between socioeconomic status and cardiovascular disease: a systematic review and meta-analysis. J Epidemiol Community Health, 2017; 71: 550-557
17) Park SJ, Kang HT, Nam CM, Park BJ, Linton JA and Lee YJ: Sex differences in the relationship between socioeconomic status and metabolic syndrome: the Korean National Health and Nutrition Examination Survey. Diabetes Res Clin Pract, 2012; 96: 400-406
18) Schoenborn CA: Health promotion and disease prevention: United States, 1985, Vital and Health Statistics. Series 10, No. 163. National Center for Health Statistics (Government Printing), Washington, USA, 1988
19) Hart JT: The inverse care law. Lancet, 1971; 1: 405-412
20) Murata C, Yamada T, Chen CC, Ojima T, Hirai H and Kondo K: Barriers to health care among the elderly in Japan. Int J Environ Res Public Health, 2010; 7: 1330-1341
21) Satoh A, Arima H, Ohkubo T, Nishi N, Okuda N, Ae R, Inoue M, Kurita S, Murakami K, Kadota A, Fujiyoshi A, Sakata K, Okamura T, Ueshima H, Okayama A and Miura K: Associations of socioeconomic status with prevalence, awareness, treatment, and control of hypertension in a general Japanese population: NIPPON DATA2010. J Hypertens, 2017; 35: 401-408
22) Kogure M, Tsuchiya N, Hozawa A, Nakaya N, Nakamura T, Miyamatsu N, Tanaka H, Wakabayashi I, Higashiyama A, Okuda N, Takashima N, Fujiyoshi A, Kadota A, Ohkubo T, Okamura T, Ueshima H, Okayama A and Miura K: Does the flushing response modify the relationship between alcohol intake and hypertension in the Japanese population? NIPPON DATA2010. Hypertens Res, 2016; 39: 670-679
23) Michikawa T, Okamura T, Nitta H, Nishiwaki Y, Takebayashi T, Ueda K, Kadota A, Fujiyoshi A, Ohkubo T, Ueshima H, Okayama A and Miura K: Cross-sectional association between exposure to particulate matter and inflammatory markers in the Japanese general population: NIPPON DATA2010. Environ Pollut, 2016; 213: 460-467
24) Ikeda N, Shibuya K and Hashimoto H: Improving population health measurement in national household surveys: a simulation study of the sample design of the comprehensive survey of living conditions of the people on health and welfare in Japan. J Epidemiol, 2011; 21: 385-390
25) Ikeda N, Takimoto H, Imai S, Miyachi M and Nishi N: Data Resource Profile: The Japan National Health and Nutrition Survey (NHNS). Int J Epidemiol, 2015; 44: 1842-1849
26) Katanoda K and Matsumura Y: National Nutrition Survey in Japan--its methodological transition and current findings. J Nutr Sci Vitaminol (Tokyo), 2002; 48: 423-432
27) Nakamura M, Sato S, Shimamoto T, Konishi M and Yoshiike N: Establishment of long-term monitoring system for blood chemistry data by the national health and nutrition survey in Japan. J Atheroscler Thromb, 2008; 15: 244-249
28) National Cholesterol Education Program: Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel Ⅲ) final report. Circulation, 2002; 106: 3143-3421
29) Seino Y, Nanjo K, Tajima N, Kadowaki T, Kashiwagi A, Araki E, Ito C, Inagaki N, Iwamoto Y, Kasuga M, Hanafusa T, Haneda M and Ueki K: Report of the committee on the classification and diagnostic criteria of diabetes mellitus. J Diabetes Investig, 2010; 1: 212-228
30) Benetou V, Chloptsios Y, Zavitsanos X, Karalis D, Naska A and Trichopoulou A: Total cholesterol and HDL-cholesterol in relation to socioeconomic status in a sample of 11,645 Greek adults: the EPIC study in Greece. European Prospective Investigation into Nutrition and Cancer. Scand J Public Health, 2000; 28: 260-265
31) Turrell G, Hewitt B, Patterson C and Oldenburg B: Measuring socio-economic position in dietary research: is choice of socio-economic indicator important? Public Health Nutr, 2003; 6: 191-200
32) Darmon N and Drewnowski A: Does social class predict diet quality? Am J Clin Nutr, 2008; 87: 1107-1117
33) Okamura T, Sugiyama D, Tanaka T and Dohi S: Worksite wellness for the primary and secondary prevention of cardiovascular disease in Japan: the current delivery system and future directions. Prog Cardiovasc Dis, 2014; 56: 515-521
34) Kagamimori S, Gaina A and Nasermoaddeli A: Socioeconomic status and health in the Japanese population. Soc Sci Med, 2009; 68: 2152-2160
35) Kondo K, Ashida T, Hirai H, Misawa J and Suzuki K:

The Relationship between Socio-economic Status and the Loss of Healthy Aging, and Relevant Gender Differences in the Japanese Older Population AGES Project Longitudinal Study.[Article in Japanese] Iryo To Shakai, 2009; 22: 19-30
36) Umberson D: Family status and health behaviors: social control as a dimension of social integration. J Health Soc Behav, 1987; 28: 306-319
37) Umberson D: Gender, marital status and the social control of health behavior. Soc Sci Med, 1992; 34: 907-917
38) Kamon Y, Okamura T, Tanaka T, Hozawa A, Yamagata Z, Takebayashi T, Kusaka Y, Urano S, Nakagawa H, Kadowaki T, Miyoshi Y, Yamato H, Okayama A and Ueshima H: Marital status and cardiovascular risk factors among middle-aged Japanese male workers: the High-risk and Population Strategy for Occupational Health Promotion (HIPOP-OHP) study. J Occup Health, 2008; 50: 348-356
39) Gupta R, Sharma KK, Gupta BK, Gupta A, Gupta RR and Deedwania PC: Educational status-related disparities in awareness, treatment and control of cardiovascular risk factors in India. Heart Asia, 2015; 7: 1-6
40) Rodriguez CJ, Cai J, Swett K, Gonzalez HM, Talavera GA, Wruck LM, Wassertheil-Smoller S, Lloyd-Jones D, Kaplan R and Daviglus ML: High Cholesterol Awareness, Treatment, and Control Among Hispanic/Latinos: Results From the Hispanic Community Health Study/Study of Latinos. J Am Heart Assoc, 2015; 4: e001867
41) Ikeda N, Saito E, Kondo N, Inoue M, Ikeda S, Satoh T, Wada K, Stickley A, Katanoda K, Mizoue T, Noda M, Iso H, Fujino Y, Sobue T, Tsugane S, Naghavi M, Ezzati M and Shibuya K: What has made the population of Japan healthy? Lancet, 2011; 378: 1094-1105
42) Chiang CE, Ferrieres J, Gotcheva NN, Raal FJ, Shehab A, Sung J, Henriksson KM and Hermans MP: Suboptimal Control of Lipid Levels: Results from 29 Countries Participating in the Centralized Pan-Regional Surveys on the Undertreatment of Hypercholesterolaemia (CEPHEUS). J Atheroscler Thromb, 2016; 23: 567-587

**Supplementary Table 1.** Characteristics of 999 men by socioeconomic status, Japan, 2010

| | Employment status | | | Marital status | | |
|---|---|---|---|---|---|---|
| | Employed ($n$=669) | Unemployed ($n$=330) | $P$ | Married ($n$=813) | Unmarried ($n$=186) | $P$ |
| Age, years | 53.3 (14.5) | 70.7 (9.6) | <0.001 | 60.8 (53.3) | 51.5 (18.6) | <0.001 |
| Body mass index, kg/m$^2$ | 23.9 (3.3) | 23.6 (3.0) | 0.20 | 23.8 (23.9) | 23.8 (3.7) | 0.35 |
| Systolic BP, mmHg | 133.4 (16.9) | 140.7 (18.6) | <0.001 | 136.3 (133.4) | 133.7 (19.3) | 0.05 |
| Diastolic BP, mmHg | 82.9 (10.5) | 81.7 (10.8) | 0.22 | 82.5 (82.9) | 82.6 (11.4) | 0.96 |
| Total cholesterol, mmol/L | 5.30 (0.86) | 5.20 (0.90) | 0.08 | 5.25 (5.30) | 5.34 (0.97) | 0.35 |
| HDL cholesterol, mmol/L | 1.49 (0.37) | 1.44 (0.41) | 0.02 | 1.47 (1.49) | 1.46 (0.41) | 0.45 |
| LDL cholesterol, mmol/L | 3.13 (0.75) | 3.00 (0.79) | 0.01 | 3.07 (3.13) | 3.18 (0.81) | 0.15 |
| Triglycerides, mmol/L [†] | 1.48 (0.99−2.16) | 1.43 (1.02−2.13) | 0.95 | 1.47 (1.03−2.10) | 1.38 (0.98−2.29) | 0.92 |
| Hypertension [§] | 323 (48.3) | 231 (70.0) | <0.001 | 459 (56.5) | 95 (51.1) | 0.21 |
| Diabetes mellitus [‡] | 70 (10.5) | 55 (16.7) | 0.01 | 103 (12.7) | 22 (11.8) | 0.85 |
| Smoking | | | | | | |
| Ex-smoker | 235 (35.3) | 173 (52.7) | <0.001 | 351 (43.5) | 57 (30.7) | 0.01 |
| Current smoker | 231 (34.7) | 61 (18.6) | | 226 (28.0) | 66 (35.5) | |
| Regular exercise [*] | 188 (28.2) | 182 (55.3) | <0.001 | 303 (37.4) | 67 (36.2) | 0.84 |
| Alcohol consumption, g/week [¶] | 63.4 (0−241.9) | 51.8 (0−190.1) | <0.001 | 63.4 (5.8−241.9) | 34.6 (0−190.1) | 0.01 |
| | Length of education | | | Equivalent household expenditure | | |
| | ≥13 years ($n$=344) | <13 years ($n$=655) | $P$ | Upper 4 quintiles ($n$=813) | Lowest quintile ($n$=186) | $P$ |
| Age, years | 52.9 (15.9) | 62.3 (14.1) | <0.001 | 59.2 (15.4) | 58.7 (15.6) | 0.59 |
| Body mass index, kg/m$^2$ | 24.0 (3.4) | 23.7 (3.0) | 0.35 | 23.8 (3.2) | 23.8 (3.1) | 0.97 |
| Systolic BP, mmHg | 131.3 (16.6) | 138.2 (18.0) | <0.001 | 135.9 (17.5) | 135.7 (18.8) | 0.82 |
| Diastolic BP, mmHg | 82.1 (10.4) | 82.8 (10.8) | 0.18 | 82.5 (10.6) | 82.8 (10.9) | 0.99 |
| Total cholesterol, mmol/L | 5.3 (0.87) | 5.3 (0.87) | 0.51 | 5.27 (0.86) | 5.26 (0.93) | 0.72 |
| HDL cholesterol, mmol/L | 1.5 (0.36) | 1.5 (0.40) | 0.27 | 1.47 (0.39) | 1.45 (0.37) | 0.79 |
| LDL cholesterol, mmol/L | 3.1 (0.75) | 3.1 (0.77) | 0.15 | 3.08 (0.74) | 3.11 (0.86) | 0.69 |
| Triglycerides, mmol/L [†] | 1.4 (0.97−2.07) | 1.48 (1.04−2.18) | 0.14 | 1.44 (1.02−2.15) | 1.52 (0.96−2.15) | 0.89 |
| Hypertension [§] | 154 (44.8) | 400 (61.1) | <0.001 | 443 (55.3) | 111 (56.1) | 0.91 |
| Diabetes mellitus [‡] | 33 (9.6) | 92 (14.1) | 0.05 | 107 (13.4) | 18 (9.1) | 0.13 |
| Smoking | | | | | | |
| Ex-smoker | 135 (39.4) | 273 (42.0) | 0.003 | 324 (40.7) | 84 (42.9) | 0.21 |
| Current smoker | 85 (24.8) | 207 (31.9) | | 228 (28.6) | 64 (32.7) | |
| Regular exercise [*] | 120 (34.9) | 250 (38.3) | 0.31 | 304 (38.1) | 66 (33.5) | 0.27 |
| Alcohol consumption, g/week [¶] | 51.8 (0−241.9) | 80.6 (0−241.9) | 0.05 | 241.9 (0−63.4) | 241.9 (0−51.8) | 0.21 |

Abbreviations: BP, blood pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein.
Data are shown as mean (standard deviation), median (interquartile range), or n (%).
[†] Triglycerides are shown as the median and interquartile range.
[§] Defined as participants who met 1 or more of the following criteria: 1) systolic BP ≥140 mm Hg and/or diastolic BP ≥90 mm Hg; or 2) receiving antihypertensive medication.
[‡] Defined as participants who met 1 or more of the following criteria: 1) fasting plasma glucose level ≥126 mg/dL (≥7.0 mmol/L); or 2) nonfasting plasma glucose level ≥200 mg/dL (≥11.1 mmol/L); 3) hemoglobin A1c ≥6.5%; or 4) receiving antidiabetic medication.
[*] Defined as participants who engaged in ≥30 minutes of exercise for ≥2 days/week for >1 year.
[¶] Alcohol consumption is shown as the median and interquartile range.

**Supplementary Table 2.** Characteristics of 1418 women by socioeconomic status, Japan, 2010

| | Employment status | | | Marital status | | |
|---|---|---|---|---|---|---|
| | Employed ($n$=611) | Unemployed ($n$=807) | $P$ | Married ($n$=1050) | Unmarried ($n$=368) | $P$ |
| Age, years | 50.0 (13.9) | 62.7 (15.0) | <0.001 | 56.5 (14.2) | 59.3 (19.7) | <0.001 |
| Body mass index, kg/m$^2$ | 22.2 (3.5) | 22.9 (3.5) | <0.001 | 22.5 (3.4) | 22.8 (3.9) | 0.52 |
| Systolic BP, mmHg | 123.6 (18.3) | 133.1 (20.2) | <0.001 | 128.2 (19.2) | 131.3 (22.0) | 0.03 |
| Diastolic BP, mmHg | 75.7 (10.4) | 78.2 (11.0) | <0.001 | 77.5 (10.7) | 76.1 (11.2) | 0.05 |
| Total cholesterol, mmol/L | 5.34 (0.91) | 5.45 (0.93) | 0.027 | 5.38 (0.90) | 5.45 (1.00) | 0.46 |
| HDL cholesterol, mmol/L | 1.78 (0.39) | 1.68 (0.39) | <0.001 | 1.73 (0.38) | 1.72 (0.44) | 0.44 |
| LDL cholesterol, mmol/L | 3.03 (0.80) | 3.13 (0.82) | 0.02 | 3.08 (0.78) | 3.11 (0.89) | 0.83 |
| Triglycerides, mmol/L [†] | 0.99 (0.68−1.47) | 1.19 (0.81−1.68) | <0.001 | 1.10 (0.75−1.56) | 1.10 (1.10−1.36) | 0.61 |
| Hypertension [§] | 173 (28.3) | 394 (48.8) | <0.001 | 388 (37.0) | 179 (48.6) | <0.001 |
| Diabetes mellitus [‡] | 33 (5.4) | 82 (10.2) | 0.002 | 78 (7.4) | 37 (10.1) | 0.14 |
| Smoking | | | | | | |
| Ex-smoker | 61 (10.0) | 62 (7.7) | <0.001 | 96 (9.2) | 27 (7.4) | 0.02 |
| Current smoker | 62 (10.2) | 40 (5.0) | | 64 (6.1) | 38 (10.4) | |
| Regular exercise [*] | 133 (21.8) | 310 (38.6) | <0.001 | 317 (30.3) | 126 (34.2) | 0.18 |
| Alcohol consumption, g/week [¶] | 0.0 (0−28.8) | 0.0 (0−5.8) | <0.001 | 0.0 (0−17.3) | 0.0 (0−17.3) | 0.23 |
| | Length of education | | | Equivalent household expenditures | | |
| | ≥13 years ($n$=445) | <13 years ($n$=973) | $P$ | Upper 4 quintiles ($n$=1139) | Lowest quintile ($n$=279) | $P$ |
| Age, years | 47.3 (13.8) | 61.8 (14.5) | <0.001 | 56.6 (15.6) | 59.7 (16.3) | <0.001 |
| Body mass index, kg/m$^2$ | 21.7 (3.1) | 23.0 (3.6) | <0.001 | 22.5 (3.4) | 22.8 (3.8) | 0.54 |
| Systolic BP, mmHg | 121.4 (17.9) | 132.5 (19.9) | <0.001 | 128.6 (19.8) | 130.8 (20.6) | 0.10 |
| Diastolic BP, mmHg | 75.4 (10.5) | 77.9 (10.9) | <0.001 | 77.3 (10.8) | 76.5 (11.0) | 0.48 |
| Total cholesterol, mmol/L | 5.29 (0.94) | 5.45 (0.91) | 0.001 | 5.42 (0.92) | 5.33 (0.93) | 0.15 |
| HDL cholesterol, mmol/L | 1.80 (0.39) | 1.69 (0.39) | <0.001 | 1.74 (0.40) | 1.68 (0.40) | 0.02 |
| LDL cholesterol, mmol/L | 3.01 (0.82) | 3.13 (0.81) | 0.002 | 3.10 (0.81) | 3.02 (0.82) | 0.10 |
| Triglycerides, mmol/L [†] | 0.93 (0.65−1.37) | 1.17 (0.81−1.67) | <0.001 | 1.07 (0.73−1.56) | 1.18 (0.78−1.70) | 0.08 |
| Hypertension [§] | 102 (22.9) | 465 (47.8) | <0.001 | 439 (38.5) | 128 (45.9) | 0.03 |
| Diabetes mellitus [‡] | 13 (2.9) | 102 (10.5) | <0.001 | 87 (7.6) | 28 (10.0) | 0.23 |
| Smoking | | | | | | |
| Ex-smoker | 48 (10.8) | 75 (7.7) | 0.10 | 99 (8.7) | 24 (8.6) | 0.96 |
| Current smoker | 27 (6.1) | 75 (7.7) | | 83 (7.3) | 19 (6.8) | |
| Regular exercise [*] | 112 (25.2) | 331 (34.1) | 0.001 | 355 (31.2) | 88 (31.7) | 0.95 |
| Alcohol consumption, g/week [¶] | 0.0 (0−40.3) | 0.0 (0−5.8) | <0.001 | 0.0 (0−17.3) | 0.0 (0−17.3) | <0.001 |

Abbreviations: BP, blood pressure; HDL, high-density lipoprotein; LDL, low-density lipoprotein.
Data are shown as mean (standard deviation), median (interquartile range), or n (%).
[†] Triglycerides are shown as the median and interquartile range.
[§] Defined as participants who met 1 or more of the following criteria: 1) systolic BP ≥140 mm Hg and/or diastolic BP ≥90 mm Hg; or 2) receiving antihypertensive medication.
[‡] Defined as participants who met 1 or more of the following criteria: 1) fasting plasma glucose level ≥126 mg/dL (≥7.0 mmol/L); or 2) nonfasting plasma glucose level ≥200 mg/dL (≥11.1 mmol/L); 3) hemoglobin A1c ≥6.5%; or 4) receiving antidiabetic medication.
[*] Defined as participants who engaged in ≥30 minutes of exercise for ≥2 days/week for >1 year.
[¶] Alcohol consumption is shown as the median and interquartile range.

**Supplementary Table 3.** Association between socioeconomic status and hypercholesterolemia prevalence stratified by age in 999 men and 1418 women

| | Men | | | Women | | |
|---|---|---|---|---|---|---|
| | Odds ratio (95% confidence intervals) | | *P* for interaction | Odds ratio (95% confidence intervals) | | *P* for interaction |
| | < 65 years | ≥ 65 years | | < 65 years | ≥ 65 years | |
| Employment status | | | | | | |
| Employed | Reference | Reference | | Reference | Reference | |
| Unemployed | 1.61 (0.88−2.94) | 0.91 (0.56−1.49) | 0.06 | 0.83 (0.58−1.18) | 1.05 (0.67−1.64) | 0.50 |
| Marital status | | | | | | |
| Married | Reference | Reference | | Reference | Reference | |
| Unmarried | 1.40 (0.85−2.31) | 0.71 (0.33−1.51) | 0.25 | 1.58 (1.01−2.45) | 1.20 (0.82−1.76) | 0.65 |
| Length of education | | | | | | |
| ≥ 13 years | Reference | Reference | | Reference | Reference | |
| < 13 years | 1.06 (0.69−1.62) | 0.71 (0.41−1.22) | 0.14 | 0.99 (0.68−1.45) | 0.72 (0.42−1.26) | 0.01 |
| Equivalent household expenditure | | | | | | |
| Upper 4 quintiles | Reference | Reference | | Reference | Reference | |
| Lowest quintile | 2.27 (1.43−3.61) | 1.02 (0.56−1.87) | 0.06 | 0.74 (0.46−1.21) | 0.94 (0.63−1.39) | 0.71 |

Model included age, history of diabetes mellitus, hypertension, and type of house (own or rent; this was only included in the analysis of household expenditures).

**Supplementary Table 4.** Multivariable-adjusted odds ratios and 95% confidence intervals for the effect of socioeconomic status on hypercholesterolemia according to sex

| | Men (*n* = 999) | | | Women (*n* = 1418) | | |
|---|---|---|---|---|---|---|
| | TC ≥ 6.21 mmol/l | LDL-C ≥ 4.14 mmol/l | NHDL-C ≥ 4.91 mmol/l | TC ≥ 6.21 mmol/l | LDL-C ≥ 4.14 mmol/l | NHDL-C ≥ 4.91 mmol/l |
| Employment status | | | | | | |
| Employed | Reference | Reference | Reference | Reference | Reference | Reference |
| Unemployed | 0.97 (0.67−1.41) | 1.04 (0.70−1.56) | 1.12 (0.75−1.66) | 0.85 (0.65−1.12) | 1.02 (0.76−1.38) | 0.97 (0.72−1.31) |
| Marital status | | | | | | |
| Married | Reference | Reference | Reference | Reference | Reference | Reference |
| Unmarried | 1.05 (0.70−1.56) | 0.92 (0.59−1.43) | 1.04 (0.68−1.59) | 1.00 (0.76−1.31) | 1.11 (0.83−1.49) | 1.08 (0.80−1.45) |
| Length of education | | | | | | |
| ≥ 13 years | Reference | Reference | Reference | Reference | Reference | Reference |
| < 13 years | 0.94 (0.67−1.32) | 1.01 (0.70−1.46) | 1.02 (0.71−1.45) | 1.01 (0.74−1.36) | 1.25 (0.89−1.76) | 1.43 (1.01−2.03) |
| Equivalent household expenditure | | | | | | |
| Upper 4 quintiles | Reference | Reference | Reference | Reference | Reference | Reference |
| Lowest quintile | 1.66 (1.16−2.38) | 1.51 (1.02−2.22) | 1.61 (1.10−2.35) | 0.82 (0.60−1.11) | 0.97 (0.70−1.34) | 0.90 (0.65−1.24) |

Abbreviations: TC, total cholesterol; LDL-C, low-density lipoprotein cholesterol; NHDL-C, non-high-density lipoprotein cholesterol.
Model included age, history of diabetes mellitus, hypertension, and type of house (own or rent; this was only included in the analysis of household expenditures).

**Supplementary Table 5.** Association between socioeconomic status and hypercholesterolemia prevalence and untreated hypercholesterolemia in women stratified by menopausal status

| | Odds ratio of hypercholesterolemia (95% confidence interval) | | *P* for interaction | Odds ratio of untreated hypercholesterolemia (95% confidence interval) | | *P* for interaction |
|---|---|---|---|---|---|---|
| | Premenopausal | Postmenopausal | | Premenopausal | Postmenopausal | |
| Employment status | | | | | | |
| Employed | Reference | Reference | | Reference | Reference | |
| Unemployed | 1.52 (0.75−3.06) | 0.91 (0.64−1.29) | 0.19 | Not calculable | 1.25 (0.71−2.21) | 0.94 |
| Marital status | | | | | | |
| Married | Reference | Reference | | Reference | Reference | |
| Unmarried | 1.82 (0.83−3.96) | 1.23 (0.87−1.73) | 0.72 | Not calculable | 1.47 (0.85−2.55) | 0.97 |
| Length of education | | | | | | |
| ≥13 years | Reference | Reference | | Reference | Reference | |
| <13 years | 1.27 (0.64−2.54) | 0.95 (0.65−1.40) | 0.38 | Not calculable | 0.62 (0.32−1.19) | 0.98 |
| Equivalent household expenditure | | | | | | |
| Upper 4 quintiles | Reference | Reference | | Reference | Reference | |
| Lowest quintile | 1.63 (0.69−3.84) | 0.70 (0.48−1.03) | 0.14 | Not calculable | 0.77 (0.41−1.46) | 0.99 |

Model included age, history of diabetes mellitus, hypertension, and type of house (own or rent; this was only included in the analysis of household expenditures).

**Supplementary Table 6.** Multivariable-adjusted odds ratio (OR) and 95% confidence interval (95%CI) for the effect of socioeconomic status on untreated hypercholesterolemia according to sex

| | Men (*n*=215) | | | Women (*n*=439) | | |
|---|---|---|---|---|---|---|
| | TC ≥6.21 mmol/l | LDL-C ≥4.14 mmol/l | NHDL-C ≥4.91 mmol/l | TC ≥6.21 mmol/l | LDL-C ≥4.14 mmol/l | NHDL-C ≥4.91 mmol/l |
| Employment status | | | | | | |
| Employed | Reference | Reference | Reference | Reference | Reference | Reference |
| Unemployed | 1.34 (0.65−2.77) | 1.68 (0.66−4.24) | 1.80 (0.79−4.10) | 1.24 (0.76−2.00) | 1.59 (0.87−2.93) | 1.50 (0.86−2.61) |
| Marital status | | | | | | |
| Married | Reference | Reference | Reference | Reference | Reference | Reference |
| Unmarried | 2.53 (1.05−6.08) | 3.03 (1.07−8.59) | 2.79 (1.12−6.93) | 1.35 (0.83−2.20) | 2.00 (1.08−3.71) | 1.82 (1.03−3.20) |
| Length of education | | | | | | |
| ≥13 years | Reference | Reference | Reference | Reference | Reference | Reference |
| <13 years | 0.94 (0.48−1.87) | 1.06 (0.47−2.40) | 0.90 (0.43−1.89) | 0.66 (0.37−1.17) | 0.81 (0.40−1.64) | 0.97 (0.50−1.89) |
| Equivalent household expenditure | | | | | | |
| Upper 4 quintiles | Reference | Reference | Reference | Reference | Reference | Reference |
| Lowest quintile | 0.67 (0.33−1.36) | 0.64 (0.27−1.53) | 0.64 (0.29−1.37) | 0.66 (0.39−1.13) | 0.87 (0.44−1.70) | 0.73 (0.39−1.37) |

Abbreviations: TC, total cholesterol; LDL-C, low-density lipoprotein cholesterol; NHDL-C, non-high-density lipoprotein cholesterol.
Model included age, history of diabetes mellitus, hypertension, and type of house (own or rent; this was only included in the analysis of household expenditures).

**Supplementary Table 7.** Association between socioeconomic status and untreated hypercholesterolemia in 215 men and 439 women stratified by age

| | Men | | | Women | | |
|---|---|---|---|---|---|---|
| | Odds ratio (95% confidence interval) | | *P* for interaction | Odds ratio (95% confidence interval) | | *P* for interaction |
| | < 65 years | ≥ 65 years | | < 65 years | ≥ 65 years | |
| Employment status | | | | | | |
| Employed | Reference | Reference | | Reference | Reference | |
| Unemployed | 1.40 (0.45−4.34) | 1.42 (0.53−3.82) | 0.95 | 1.01 (0.50−2.04) | 1.57 (0.79−3.13) | 0.52 |
| Marital status | | | | | | |
| Married | Reference | Reference | | Reference | Reference | |
| Unmarried | 3.71 (1.12−12.33) | 2.20 (0.46−10.44) | 0.22 | 4.63 (1.30−16.42) | 0.90 (0.50−1.61) | 0.01 |
| Length of education | | | | | | |
| ≥ 13 years | Reference | Reference | | Reference | Reference | |
| < 13 years | 1.05 (0.42−2.67) | 0.84 (0.30−2.33) | 0.82 | 0.91 (0.39−2.08) | 0.52 (0.23−1.14) | 0.56 |
| Equivalent household expenditure | | | | | | |
| Upper 4 quintiles | Reference | Reference | | Reference | Reference | |
| Lowest quintile | 0.72 (0.29−1.76) | 0.62 (0.19−2.09) | 0.71 | 0.51 (0.20−1.33) | 0.73 (0.38−1.38) | 0.72 |

Model included age, history of diabetes mellitus, hypertension, and type of house (own or rent; this was only included in the analysis of household expenditures).