Is nutritional labeling associated with individual health? The effects of labeling-based awareness on dyslipidemia risk in a South Korean population

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Abstract

Background: In 1995, the South Korean government made nutrition labeling compulsory, which has positively impacted patients with certain chronic diseases, such as dyslipidemia. We investigated the association between nutrition labeling-based awareness and the risk of dyslipidemia among individuals not yet diagnosed.

Methods: Our study used data from the fifth Korea National Health and Nutrition Examination Surveys administered during 2010–2014 (n = 17,687). We performed multiple or logistic regression analysis to examine the association between nutritional analysis and various outcome variables.

Results: Approximately 70 % of the respondents (n = 11,513) were familiar with nutrition labeling, of which 20 % (n = 3172) decided what food to buy based on that information. This awareness yielded mostly positive results on outcome indicators, such as triglyceride and high-density lipoprotein cholesterol levels. In general, individuals who used nutritional labels to make decisions regarding food purchases had a lower risk of dyslipidemia than individuals who did not (OR: 0.806, 95 % CI: 0.709–0.917).

Conclusion: Utilizing nutrition labels for making food choices correlated with a lower risk of dyslipidemia in certain subgroups. Based on our findings, we recommend that health policymakers and medical professionals consider promoting nutrition labeling as an alternative method for managing certain chronic diseases in South Korean patients.

Keywords: Nutrition labeling, Health policy perception, Dyslipidemia, Hyperlipidemia

Background

During the past 30 years, South Korea has experienced evolving health care perspectives, with a recent focus on chronic diseases. Although many health care professionals have studied treatment options extensively, some chronic diseases persist in South Korean patients [1]. Therefore, developing prevention strategies for managing risk factors, such as hypertension, diabetes mellitus, and dyslipidemia, may be important for controlling these diseases [2–4].

Dyslipidemia is a state of abnormal amounts of lipids in the blood and is characterized by conditions such as hypercholesterolemia, hypertriglyceridemia, increased low-density lipoprotein (LDL) cholesterolemia, and decreased high-density lipoprotein (HDL) cholesterolemia [5]. Dyslipidemia can be managed by diet, exercise, and sometimes drug injections, depending on the health of the patient [6]. However, based on previous studies in South Korea, the prevalence rate of dyslipidemia has gradually increased since 2000 [7]. Although not necessarily harmful itself, the condition is a major risk factor for various cardiovascular...
diseases (CVD) [8]. Mortality due to CVD has also increased in recent years, making it the second most common cause of death in South Korea [9]. Therefore, it is essential to investigate alternatives for effectively preventing and/or managing dyslipidemia.

In 1995, the South Korean government made nutrition labeling compulsory. Nutrition labeling is a type of food labeling [10] that describes the nutritional properties of processed foods to help consumers make a reasonable choice in purchasing food based on its nutritional values [11]. Labeling also protects consumers from dishonest advertisement by providing exact nutrition information. Previous studies show that nutrition labeling affects food intake with respect to total fat, carbohydrates, and saturated fat and that awareness of nutrition facts and may be helpful in managing certain chronic diseases [12–14].

Because nutrition labeling has since expanded in South Korea, some positive effects on patients with chronic diseases, particularly dyslipidemia, have been linked closely to dietary patterns [15, 16]. Despite increased dyslipidemia prevalence and the expansion of nutrition labeling in South Korea, few studies have investigated their relationship. As introducing the nutrition labelling system in South Korea, we expected that the health information related to food consumption would be well provided to South Korean. Therefore, South Korean would easily access to health information which might be helpful in well managing their health compared to past. Based on our hypothesis that nutrition labeling may help prevent dyslipidemia, we analyzed the potential association between nutrition labeling-based awareness and the prevalence of dyslipidemia among individuals not yet diagnosed.

Methods

Study population
This study used data from the fifth Korea National Health and Nutrition Examination Surveys (KNHANES V/VI 2010–14), which are cross-sectional questionnaires that have been administered annually since 1998 by the Korea Centers for Disease Control and Prevention (KCDC) to assess the health and nutritional status of the Korean population. This survey is composed of three parts: Health Interview Survey, Health Examination, and Nutrition Survey. The health examination survey collected the information about anthropometric index, blood pressure, blood test, urine test, dental examination, pulmonary function test, optical test, and hearing test. These tests were performed through visiting examination using vehicle for health examination. The nutrition survey was conducted through additional visiting research of investigator after Health Interview Survey and Health Examination. The nutrition survey including average amount of daily fat intake was consisted to dietary pattern, dietary supplements, nutrition knowledge, food safety, food intake of the day before survey (24 h recall method), and food frequency questionnaire. A stratified multi-stage cluster-sampling design was used to obtain a nationally representative sample from the three parts of the survey. The overall response rates were 81.9 % in 2010, 80.4 % in 2011, 80.0 % in 2012, 79.3 % in 2013, and 77.8 % in 2014 and included 41,101 total respondents. Individuals not tested for dyslipidemia indicators and those under the age of 30 were excluded from the study. In addition, we excluded respondents diagnosed with dyslipidemia before the survey. Thus, we included 17,687 eligible participants in the study.

Variables analyzed
The outcome variables analyzed in this study included four indicators of dyslipidemia: total cholesterol (TC), LDL cholesterol, HDL cholesterol, and triglyceride (TG) levels. Although TC, TG, and HDL cholesterol levels were measured on the day of investigation. This blood test was measured through fasting blood test (minimum 8 h and recommended 12 h after eating). The LDL cholesterol levels were not measured, so were instead calculated using the Friedewald formula. This methods also relatively efficient methods than the ultracentrifugal measurement of LDL cholesterol [17]. We first considered each indicator as a continuous variable and then defined dyslipidemia as the presence of at least one indicator meeting the following diagnostic criteria: TC≥200 mg/dL, LDL cholesterol≥130 mg/dL, HDL cholesterol≤40 mg/dL, or TG≥150 mg/dL [18].

The primary independent variable was the respondents’ awareness regarding nutrition labeling, which we defined as one of three levels: 1) “unaware of nutrition facts (lowest awareness)”; 2) “aware of nutrition facts but does not check them when making food purchase/checks nutrition facts but does not make labeling-dependent purchase decisions”; or 3) “checks nutrition facts and makes labeling-dependent purchase decisions (highest awareness)”. We included other independent variables to investigate the association between labeling awareness and dyslipidemia. These additional variables were sex, age, educational level, economic activity, household income, body mass index (BMI), aerobic exercise habits, smoking status, high risk drinking, family history of hyperlipidemia, stress awareness, subjective health, average amount of daily fat intake, frequency of eating out, and survey year [19–21]. Age was divided by 10-year increments or grouped as more than 60 years old. Educational level was classified as no high school graduation, bachelor’s degree, and master’s degree or above. BMI was categorized into three groups based on obesity criteria in South Korea (<23, 23–25,
| Awareness regarding nutrition labelling | Checks nutrition facts and makes labeling-dependent purchase decisions | Checks nutrition facts but does not make labeling-dependent purchase decisions/ Aware of nutrition facts but does not check them when making food purchase decisions | Unaware of nutrition facts | $P$-value |
|----------------------------------------|-------------------------------------------------|-------------------------------------------------|--------------------------|----------|
| Variables | N/Mean %/SD | N/Mean %/SD | N/Mean %/SD | |
| **Sex** | | | | |
| Male | 645 8.76 | 3,739 50.78 | 2,979 40.46 | <.0001 |
| Female | 2,527 24.48 | 4,602 44.58 | 3,195 30.95 | |
| **Age (years)** | | | | |<.0001 |
| 30–39 | 1,406 34.19 | 2,402 58.41 | 304 7.39 | |
| 40–49 | 1,014 25.76 | 2,367 60.14 | 555 14.10 | |
| 50–59 | 524 13.88 | 2,001 53.02 | 1,249 33.09 | |
| 60+ | 228 3.89 | 1,571 26.79 | 4,066 69.33 | |
| **Educational level** | | | | |<.0001 |
| Under high school graduation | 1,313 11.25 | 4,881 41.83 | 5,476 46.92 | |
| Bachelor’s degree | 1,635 30.91 | 3,035 57.37 | 620 11.72 | |
| Master’s degree or above | 224 30.81 | 425 58.46 | 78 10.73 | |
| **Economic activity** | | | | |<.0001 |
| Unemployed | 1,389 20.23 | 2,706 39.41 | 2,772 40.37 | |
| Employed | 1,783 16.48 | 5,635 52.08 | 3,402 31.44 | |
| **Household income** | | | | |<.0001 |
| Low | 172 5.09 | 869 25.70 | 2,340 69.21 | |
| Mid-low | 715 15.92 | 2,124 47.29 | 1,652 36.78 | |
| Mid-high | 1,085 22.04 | 2,599 52.79 | 1,239 25.17 | |
| High | 1,200 24.53 | 2,749 56.19 | 943 19.28 | |
| **BMI** | | | | |<.0001 |
| <23 | 1,629 20.62 | 3,814 48.28 | 2,456 31.09 | |
| 23–25 | 687 16.21 | 1,951 46.04 | 1,600 37.75 | |
| >25 | 856 15.42 | 2,576 46.41 | 2,118 38.16 | |
| **Aerobic exercise habits** | | | | |<.0001 |
| Yes | 937 21.97 | 2,115 49.59 | 1,213 28.44 | |
| No | 2,235 16.65 | 6,226 46.39 | 4,961 31.96 | |
| **Smoking status** | | | | |<.0001 |
| Non-smoker | 2,821 19.73 | 6,536 45.71 | 4,943 34.57 | |
| Smoker | 351 10.36 | 1,805 53.29 | 1,231 36.34 | |
| **High risk drinking** | | | | |<.0001 |
| No | 2,935 18.39 | 7,375 46.22 | 5,646 35.38 | |
| Yes | 237 13.69 | 966 55.81 | 528 30.50 | |
| **Family history for hyperlipidemia** | | | | |<.0001 |
| No | 2,915 17.22 | 7,941 46.91 | 6,073 35.87 | |
| Yes | 257 33.91 | 400 52.77 | 101 13.32 | |
| **Survey year** | | | | |<.0001 |
| 2010 | 725 18.28 | 1,721 43.39 | 1,520 38.33 | |
| 2011 | 623 15.73 | 1,735 43.81 | 1,602 40.45 | |
| 2012 | 621 17.25 | 1,675 46.54 | 1,303 36.20 | |
and >25). Aerobic exercise habits were based on the amount of aerobic exercise per week, with 150 min of exercise as the cutoff. The smoking status was defined as follows. Smoker group included the current smoker regardless the amount of smoking. Non-smoker group included the ex-smoker and people who have never smoke in their life. The high risk drinking was defined as people who consume more than seven (for males) or five (for females) drinks on a single occasion at least twice a week. The average amount of daily fat intake was calculated based on food intake of the day before survey (24 h recall method). Respondents were recorded the information about food intake of the day before survey, and investigator calculated the nutrient component based on this information. The frequency of eating out was categorized based on five times a week. Stress awareness was defined as the respondents’ daily stress awareness and was classified as “high” or “low”. Subjective health status was classified as “bad,” “normal,” or “good.”

Statistical analysis
We first examined the distribution of values by frequency and percentage for categorical variables or mean and standard deviation for continuous variables, showed the association between other independent variables and awareness of nutrition labelling. Next, we performed ANOVA for continuous variables to determine their relationship with the independent variables by comparing the means and standard deviations of the outcome variables. We also performed Chi-square tests to determine relationships with dyslipidemia diagnosis. Finally, multiple regression analysis was used to examine the association between awareness of nutrition labeling and dyslipidemia indicators while controlling for potential confounding (independent) variables described above. We then performed logistic regression analysis of dyslipidemia risk based on the four dyslipidemia indicators. In addition, we carried out subgroup multiple logistic regression analysis by sex, age, educational level, BMI, and subjective health status to examine differences in nutrition labeling-mediated awareness and dyslipidemia risk. Sampling weights assigned to each participant were applied in the analyses to generalize the sampled data.

Results
The data used in this study included 17,687 unique responses to the KNHANES V/VI from 2010 to 2014. Table 1 shows the general characteristics of our study participants by awareness of nutrition labelling. Approximately 70 % of respondents were aware of nutrition labelling, but most did not actively check nutrition labels or make food purchasing decisions based on nutrition labels. Only about 20 % of these respondents made nutrition label-dependent food purchasing decisions. Females were more frequently in higher awareness level in nutrition labelling than males. The people with younger age, higher educational level, and higher income were more recognized for nutrition labelling than others. In addition, people who had more healthy behaviors were more frequent in higher awareness of nutrition labelling.

Table 2 shows associations between the independent and outcome variables. The average values for dyslipidemia indicators (TC, TG, HDL cholesterol, and LDL cholesterol) were 190.88, 137.42, 50.86, and 112.54 mg/dL, respectively. Individuals with higher awareness of nutrition labeling had positive association with low TC,
Table 2 The association between awareness on nutrition labelling and 4 indicators related to dyslipidemia or diagnosis of dyslipidemia

| Variables                                             | Total cholesterol (mg/dL) | Triglyceride (mg/dL) | HDL cholesterol (mg/dL) | LDL cholesterol (mg/dL) | Dyslipidemia | P-value |
|-------------------------------------------------------|---------------------------|----------------------|-------------------------|-------------------------|--------------|---------|
|                                                       | Mean          | SD        | P-value | Mean          | SD        | P-value | Mean          | SD        | P-value | N  | %    | N  | %    | P-value |
| Checks nutrition facts and makes labeling-dependent    | 188.53        | 34.01    | 0.0399  | 111.89        | 79.41    | <.0001  | 55.48        | 12.75    | <.0001  | 110.68 | 30.10 | 0.0006 | 1,536 | 48.42 | 1,636 | 51.58 | <.0001 |
| purchase decisions                                    |               |           |         |               |           |          |               |           |          |       |      |       |       |         |
| Checks nutrition facts but does not                   | 191.32        | 34.24    | 129.82  | 102.12        | 52.80    | 12.52   | 112.55       | 31.57    | 4.778   | 57.28  | 3.563  | 42.72 |         |       |       |       |         |
| make labeling-dependent purchase decisions/Aware of   |               |           |         |               |           |          |               |           |          |       |      |       |       |         |
| nutrition facts but does not check them when making   |               |           |         |               |           |          |               |           |          |       |      |       |       |         |
| food purchase decisions                                |               |           |         |               |           |          |               |           |          |       |      |       |       |         |
| Unaware of nutrition facts                            | 192.54        | 36.35    | 144.53  | 109.29        | 50.13    | 12.25   | 113.50       | 33.74    | 4.108   | 66.54  | 2.066  | 33.46 |         |       |       |       |         |
| Sex                                                   |               |           |         |               |           |          |               |           |          |       |      |       |       |         |
| Male                                                  | 189.06        | 34.48    | <.0001  | 155.43        | 123.33   | <.0001  | 48.90        | 11.82    | <.0001  | 109.08 | 33.39  | <.0001 | 4,777  | 64.88 | 2,586 | 35.12 | <.0001 |
| Female                                                | 192.80        | 35.24    | 114.85  | 78.70         | 54.81    | 12.58   | 115.02       | 30.92    | 5.645   | 54.68  | 4,679  | 45.32 |         |       |       |       |         |
| Age (years)                                           |               |           |         |               |           |          |               |           |          |       |      |       |       |         |
| 30–39                                                 | 183.28        | 33.23    | <.0001  | 116.04        | 97.17    | <.0001  | 54.78        | 12.67    | <.0001  | 105.30 | 29.70  | <.0001 | 1,816  | 44.16 | 2,296 | 55.84 | <.0001 |
| 40–49                                                 | 190.31        | 33.50    | 130.36  | 113.12        | 53.24    | 12.41   | 110.99       | 31.25    | 2.151   | 54.65  | 1,785  | 45.35 |         |       |       |       |         |
| 50–59                                                 | 199.50        | 34.47    | 142.52  | 109.54        | 52.56    | 12.75   | 118.43       | 33.11    | 2.595   | 68.76  | 1,179  | 31.24 |         |       |       |       |         |
| 60+                                                   | 192.14        | 36.17    | 136.74  | 89.46         | 49.90    | 12.18   | 114.89       | 32.61    | 3.860   | 65.81  | 2.005  | 34.19 |         |       |       |       |         |
| Educational level                                     |               |           |         |               |           |          |               |           |          |       |      |       |       |         |
| Under high school graduation                          | 192.88        | 35.56    | 0.1972  | 136.69        | 104.97   | 0.0105  | 51.73        | 12.58    | 0.1640  | 113.82 | 33.02  | 0.0338 | 7.343  | 62.92 | 4,327 | 37.08 | <.0001 |
| Bachelor's degree                                     | 187.73        | 33.61    | 121.24  | 94.43         | 53.75    | 12.57   | 109.74       | 30.09    | 2.679   | 50.64  | 2,611  | 49.36 |         |       |       |       |         |
| Master’s degree or above                              | 190.55        | 33.42    | 128.79  | 93.64         | 52.14    | 12.55   | 112.66       | 30.07    | 4.00    | 55.02  | 327    | 44.98 |         |       |       |       |         |
| Economic activity                                     |               |           |         |               |           |          |               |           |          |       |      |       |       |         |
| Unemployed                                            | 191.26        | 36.26    | 0.5049  | 125.39        | 87.09    | 0.0150  | 52.62        | 12.87    | 0.0188  | 113.57 | 32.13  | 0.1766 | 4.024  | 58.60 | 2,843 | 41.40 | 0.4833 |
| Employed                                              | 191.23        | 34.14    | 135.77  | 109.81        | 52.17    | 12.44   | 111.90       | 32.08    | 6.398   | 59.13  | 4,422  | 40.87 |         |       |       |       |         |
| Household income                                      |               |           |         |               |           |          |               |           |          |       |      |       |       |         |
| Low                                                   | 191.86        | 36.26    | 0.5209  | 140.45        | 96.60    | 0.2011  | 50.15        | 12.60    | 0.0143  | 113.62 | 33.65  | 0.3923 | 2.249  | 66.52 | 1,132 | 33.48 | <.0001 |
| Mid-low                                               | 191.04        | 35.62    | 133.31  | 110.04        | 52.20    | 12.58   | 112.18       | 32.03    | 2.634   | 58.65  | 1,857  | 41.35 |         |       |       |       |         |
| Mid-high                                              | 190.33        | 34.21    | 128.97  | 101.42        | 52.99    | 12.49   | 111.55       | 32.33    | 2.750   | 55.86  | 2,173  | 44.14 |         |       |       |       |         |
| High                                                  | 191.92        | 34.22    | 127.06  | 97.02         | 53.36    | 12.59   | 113.15       | 30.80    | 2.789   | 57.01  | 2,103  | 42.99 |         |       |       |       |         |
| BMI                                                   |               |           |         |               |           |          |               |           |          |       |      |       |       |         |
| <23                                                   | 185.60        | 33.75    | <.0001  | 106.94        | 79.58    | <.0001  | 55.72        | 13.07    | <.0001  | 108.50 | 30.34  | <.0001 | 3,666  | 46.41 | 4,233 | 53.59 | <.0001 |
| Activity                        | Mean | SD  | P-value | Mean | SD  | P-value | Mean | SD  | P-value | Mean | SD  | P-value | Mean | SD  | P-value |
|--------------------------------|------|-----|---------|------|-----|---------|------|-----|---------|------|-----|---------|------|-----|---------|
| Aerobic exercise habits        |      |     |         |      |     |         |      |     |         |      |     |         |      |     |         |
| Yes                           | 190.61 | 33.52 | <.0001  | 126.55 | 96.47 | <.0001  | 52.42 | 12.90 | <.0001  | 111.87 | 31.27 | <.0001  | 2425  | 56.86 | 43.14  |
| No                            | 191.45 | 35.43 | <.0001  | 133.39 | 103.28 | <.0001  | 52.01 | 12.50 | <.0001  | 112.76 | 32.36 | <.0001  | 7997  | 59.58 | 40.42  |
| Smoking status                |      |     |         |      |     |         |      |     |         |      |     |         |      |     |         |
| Non-smoker                    | 191.20 | 34.87 | <.0001  | 123.16 | 89.01 | <.0001  | 52.98 | 12.51 | <.0001  | 113.59 | 31.11 | <.0001  | 8152  | 57.01 | 42.99  |
| Smoker                        | 191.41 | 35.42 | <.0001  | 167.97 | 137.71 | <.0001  | 49.67 | 12.67 | <.0001  | 108.15 | 35.69 | <.0001  | 2270  | 67.02 | 32.98  |
| High risk drinking            |      |     |         |      |     |         |      |     |         |      |     |         |      |     |         |
| No                            | 190.96 | 34.90 | <.0001  | 125.77 | 89.46 | <.0001  | 52.13 | 12.44 | <.0001  | 113.68 | 31.34 | <.0001  | 9254  | 58.00 | 42.00  |
| Yes                           | 193.88 | 35.57 | <.0001  | 186.79 | 169.14 | <.0001  | 54.38 | 13.89 | <.0001  | 102.14 | 36.89 | <.0001  | 1168  | 67.48 | 32.52  |
| Family history for hyperlipidemia |      |     |         |      |     |         |      |     |         |      |     |         |      |     |         |
| No                            | 191.12 | 34.91 | <.0001  | 132.05 | 102.08 | <.0001  | 52.24 | 12.58 | 0.0002  | 112.46 | 32.11 | <.0001  | 9995  | 59.04 | 40.96  |
| Yes                           | 194.05 | 36.41 | <.0001  | 124.93 | 92.97  | <.0001  | 54.65 | 13.00 | <.0001  | 114.41 | 32.06 | <.0001  | 427   | 56.33 | 43.67  |
| Survey year                   |      |     |         |      |     |         |      |     |         |      |     |         |      |     |         |
| 2010                          | 190.41 | 35.86 | 0.0245  | 130.30 | 98.76  | 0.0539  | 52.71 | 12.77 | <.0001  | 111.64 | 32.60 | 0.0032  | 2294  | 57.84 | 42.16  |
| 2011                          | 192.84 | 36.05 | 0.0007  | 132.72 | 106.89 | <.0001  | 52.93 | 12.80 | 0.0001  | 113.36 | 32.66 | 0.0352  | 2352  | 59.39 | 40.61  |
| 2012                          | 191.79 | 34.76 | <.0001  | 130.01 | 98.86  | 0.0167  | 51.46 | 12.45 | <.0001  | 114.33 | 31.93 | <.0001  | 2187  | 60.77 | 39.23  |
| 2013                          | 190.80 | 34.06 | <.0001  | 133.48 | 106.04 | <.0001  | 52.15 | 12.30 | <.0001  | 111.95 | 32.09 | <.0001  | 1879  | 59.35 | 40.65  |
| 2014                          | 190.05 | 33.47 | <.0001  | 132.59 | 97.21  | <.0001  | 52.36 | 12.62 | <.0001  | 111.17 | 30.81 | <.0001  | 1710  | 57.08 | 42.92  |
| Stress awareness              |      |     |         |      |     |         |      |     |         |      |     |         |      |     |         |
| Low                           | 191.18 | 34.87 | 0.1373  | 131.38 | 99.14  | 0.3396  | 52.23 | 12.58 | 0.0746  | 112.67 | 32.04 | 0.2953  | 8020  | 59.25 | 40.75  |
| High                          | 191.46 | 35.33 | <.0001  | 132.92 | 109.72 | <.0001  | 52.73 | 12.69 | <.0001  | 112.14 | 32.32 | <.0001  | 2402  | 57.88 | 42.12  |
| Subjective health status      |      |     |         |      |     |         |      |     |         |      |     |         |      |     |         |
| Good                          | 191.50 | 34.39 | 0.0008  | 126.37 | 95.89  | 0.0031  | 53.29 | 12.74 | <.0001  | 112.93 | 31.31 | 0.0005  | 3316  | 57.01 | 42.99  |
| Normal                        | 191.20 | 34.43 | <.0001  | 133.28 | 106.44 | <.0001  | 52.25 | 12.57 | <.0001  | 112.30 | 32.02 | <.0001  | 5173  | 59.20 | 40.80  |
| Bad                           | 190.88 | 37.50 | <.0001  | 137.42 | 98.28  | <.0001  | 50.86 | 12.33 | <.0001  | 112.54 | 33.77 | <.0001  | 1933  | 61.72 | 38.28  |
| The frequency of eating out    |      |     |         |      |     |         |      |     |         |      |     |         |      |     |         |
| Less than four times a week    | 191.43 | 35.53 | 0.0007  | 128.23 | 96.74  | 0.8791  | 52.55 | 12.76 | 0.0980  | 113.24 | 32.19 | 0.0001  | 7138  | 58.92 | 41.08  |
| More than five times a week    | 190.83 | 33.75 | <.0001  | 139.38 | 111.40 | <.0001  | 51.90 | 12.28 | <.0001  | 111.05 | 31.86 | <.0001  | 3284  | 58.94 | 41.06  |
| Total                         | 191.243| 34.976| <.0001  | 131.74 | 101.717| <.0001  | 52.347| 12.611| <.0001  | 112.548| 32.105| <.0001  | 10422 | 58.92 | 41.08  |
| Variables | Total cholesterol (mg/dL) | Triglyceride (mg/dL) | HDL cholesterol (mg/dL) | LDL cholesterol (mg/dL) | Dyslipidemia | OR | 95 % CI | P-value |
|-----------|--------------------------|----------------------|-------------------------|-------------------------|--------------|----|--------|--------|
|           | β | SE | P-value | β | SE | P-value | β | SE | P-value | OR | 95 % CI | P-value |
| Awareness on nutrition labelling | | | | | | | | | | | | |
| Checks nutrition facts and makes labeling-dependent purchase decisions | 0.837 | 1.056 | 0.4280 | −11.803 | 3.061 | 0.0001 | 1.259 | 0.357 | 0.0004 | 1.938 | 0.994 | 0.0515 | 0.806 | 0.709 | 0.917 | 0.0011 |
| Checks nutrition facts but does not make labeling-dependent purchase decisions/Aware of nutrition facts but does not check them when making food purchase decisions | 2.350 | 0.783 | 0.0028 | −7.170 | 2.725 | 0.0086 | 0.799 | 0.249 | 0.0014 | 2.985 | 0.774 | 0.0001 | 0.919 | 0.828 | 1.020 | 0.1110 |
| Unaware of nutrition facts | Ref | - | - | Ref | - | - | Ref | - | - | 1.000 | - | - | - | |
| Sex | | | | | | | | | | | | | | |
| Male | −5.197 | 0.833 | <.0001 | 27.026 | 2.565 | <.0001 | −6.089 | 0.279 | <.0001 | −4.513 | 0.768 | <.0001 | 1.395 | 1.265 | 1.537 | <.0001 |
| Female | Ref | - | - | Ref | - | - | Ref | - | - | 1.000 | - | - | - | |
| Age (years) | | | | | | | | | | | | | | |
| 30–39 | −10.395 | 1.105 | <.0001 | −6.634 | 3.267 | 0.0426 | 1.822 | 0.372 | <.0001 | −10.890 | 1.056 | <.0001 | 0.497 | 0.432 | 0.572 | <.0001 |
| 40–49 | −5.299 | 1.035 | <.0001 | 6.350 | 3.465 | 0.0672 | 0.706 | 0.367 | 0.0544 | −7.275 | 1.001 | <.0001 | 0.678 | 0.596 | 0.772 | <.0001 |
| 50–59 | 3.804 | 0.985 | 0.0001 | 11.906 | 3.065 | 0.0001 | 1.012 | 0.322 | 0.0018 | 0.411 | 0.940 | 0.6623 | 1.168 | 1.025 | 1.331 | 0.0198 |
| 60+ | Ref | - | - | Ref | - | - | Ref | - | - | 1.000 | - | - | - | |
| Educational level | | | | | | | | | | | | | | |
| Under high school graduation | −2.553 | 1.535 | 0.0966 | 1.013 | 4.692 | 0.8291 | 0.221 | 0.548 | 0.6871 | −2.976 | 1.456 | 0.0413 | 0.983 | 0.801 | 1.206 | 0.8674 |
| Bachelor’s degree | −2.206 | 1.508 | 0.1438 | −3.499 | 4.603 | 0.4474 | 0.206 | 0.537 | 0.7017 | −1.712 | 1.417 | 0.2273 | 0.954 | 0.776 | 1.173 | 0.6558 |
| Master’s degree or above | Ref | - | - | Ref | - | - | Ref | - | - | 1.000 | - | - | - | |
| Economic activity | | | | | | | | | | | | | | |
| Unemployed | 0.749 | 0.794 | 0.3461 | 4.398 | 2.187 | 0.0446 | −0.464 | 0.251 | 0.0653 | 0.333 | 0.729 | 0.6480 | 1.153 | 1.049 | 1.267 | 0.0031 |
| Employed | Ref | - | - | Ref | - | - | Ref | - | - | 1.000 | - | - | - | |
| Household income | | | | | | | | | | | | | | |
| Low | 0.258 | 1.039 | 0.8042 | 2.602 | 3.436 | 0.4491 | −0.585 | 0.389 | 0.1331 | 0.323 | 1.031 | 0.7544 | 1.076 | 0.946 | 1.223 | 0.2677 |
| Mid-low | −0.302 | 0.876 | 0.7302 | −0.916 | 3.057 | 0.7644 | −0.196 | 0.303 | 0.5180 | 0.077 | 0.805 | 0.9237 | 0.926 | 0.829 | 1.035 | 0.1771 |
| Mid-high | 0.064 | 0.848 | 0.9399 | −2.031 | 2.702 | 0.4524 | 0.012 | 0.269 | 0.9648 | 0.458 | 0.808 | 0.5705 | 0.953 | 0.858 | 1.059 | 0.3729 |
| High | Ref | - | - | Ref | - | - | Ref | - | - | 1.000 | - | - | - | |
| BMI | | | | | | | | | | | | | | |
| <23 | −13.918 | 0.749 | <.0001 | −55.011 | 2.572 | <.0001 | 6.944 | 0.253 | <.0001 | −9.860 | 0.725 | <.0001 | 0.306 | 0.280 | 0.335 | <.0001 |
| 23–25 | −7.322 | 0.869 | <.0001 | −27.998 | 3.190 | <.0001 | 2.754 | 0.265 | <.0001 | −4.477 | 0.795 | <.0001 | 0.566 | 0.509 | 0.629 | <.0001 |
| >25 | Ref | - | - | Ref | - | - | Ref | - | - | 1.000 | - | - | - | |
### Table 3 The results of multiple regression or logistic regression analysis to examine the association between awareness on nutrition labelling and outcome variables (Continued)

| Aerobic exercise habits | Yes | Ref | - | - | Ref | - | - | Ref | - | - | 1.000 | - | - | - |
|-------------------------|-----|-----|---|---|-----|---|---|-----|---|---|-------|---|---|---|
| No                      | 0.783 | 0.752 | 0.2981 | 10.527 | 2.478 | <0.001 | -1.456 | 0.255 | <0.001 | 0.134 | 0.717 | 0.8517 | 1.090 | 0.992 | 1.199 | 0.0731 |
| Smoking status          |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Non-smoker              | Ref | - | - | Ref | - | - | Ref | - | - | 1.000 | - | - | - |
| Smoker                  | 3.364 | 0.916 | 0.0003 | 26.004 | 3.516 | <0.001 | -1.325 | 0.301 | <0.001 | -0.512 | 0.910 | 0.5739 | 1.445 | 1.292 | 1.616 | <0.001 |
| High risk drinking      |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| No                      | Ref | - | - | Ref | - | - | Ref | - | - | 1.000 | - | - | - |
| Yes                     | 2.614 | 1.123 | 0.0202 | 41.059 | 5.895 | <0.001 | 4.954 | 0.366 | <0.001 | -10.553 | 1.190 | <0.001 | 1.229 | 1.066 | 1.416 | 0.0046 |
| Family history for hyperlipidemia |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| No                      | Ref | - | - | Ref | - | - | Ref | - | - | 1.000 | - | - | - |
| Yes                     | 6.016 | 1.501 | <0.001 | 5.369 | 4.264 | 0.2083 | 0.477 | 0.531 | 0.3687 | 4.465 | 1.380 | 0.0013 | 1.307 | 1.096 | 1.560 | 0.0028 |
| Survey year             |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| 2010                    | 0.362 | 1.093 | 0.7404 | -9.251 | 3.187 | 0.0038 | 1.093 | 0.354 | 0.0021 | 1.120 | 1.007 | 0.2663 | 0.998 | 0.878 | 1.134 | 0.9711 |
| 2011                    | 1.526 | 1.090 | 0.1619 | -6.695 | 3.336 | 0.0451 | 1.137 | 0.349 | 0.0012 | 1.728 | 1.003 | 0.0854 | 1.000 | 0.876 | 1.142 | 0.992 |
| 2012                    | 1.877 | 1.114 | 0.0922 | -5.973 | 3.523 | 0.0904 | -0.092 | 0.389 | 0.8141 | 3.163 | 1.055 | 0.0028 | 1.117 | 0.975 | 1.278 | 0.1106 |
| 2013                    | -0.479 | 1.062 | 0.6523 | -4.680 | 3.494 | 0.1807 | 0.513 | 0.353 | 0.1464 | -0.056 | 1.028 | 0.9567 | 1.030 | 0.900 | 1.179 | 0.6653 |
| 2014                    | Ref | - | - | Ref | - | - | Ref | - | - | 1.000 | - | - | - |
| Stress awareness        |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Low                     | Ref | - | - | Ref | - | - | Ref | - | - | 1.000 | - | - | - |
| High                    | 0.443 | 0.757 | 0.5589 | 2.219 | 2.994 | 0.4588 | 0.281 | 0.263 | 0.2850 | -0.282 | 0.732 | 0.6998 | 0.994 | 0.907 | 1.089 | 0.8906 |
| Subjective health status|     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Good                    | 0.979 | 1.014 | 0.3347 | -8.120 | 3.109 | 0.0092 | 1.710 | 0.330 | <0.001 | 0.894 | 0.853 | 0.2949 | 0.942 | 0.829 | 1.070 | 0.3556 |
| Normal                  | 0.972 | 0.978 | 0.3209 | -2.164 | 2.945 | 0.4627 | 0.761 | 0.299 | 0.0109 | 0.643 | 0.855 | 0.4521 | 1.056 | 0.937 | 1.190 | 0.3686 |
| Bad                     | Ref | - | - | Ref | - | - | Ref | - | - | 1.000 | - | - | - |
| Average amount of daily fat intake |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Less than four times a week | 0.040 | 0.011 | 0.0002 | -0.030 | 0.036 | 0.4076 | 0.008 | 0.003 | 0.0139 | 0.038 | 0.010 | 0.0002 | 1.000 | 0.999 | 1.001 | 0.9479 |
| More than five times a week | 1.374 | 0.801 | 0.0867 | -2.755 | 2.835 | 0.3314 | 0.074 | 0.258 | 0.7748 | 1.851 | 0.794 | 0.0199 | 1.043 | 0.943 | 1.153 | 0.4132 |
low TG, high HDL cholesterol, low LDL cholesterol, and less diagnosis of dyslipidemia than individuals with lower awareness. Likewise, subjects with dyslipidemia were more likely to have lower awareness of nutrition labeling. In addition, older or male individuals were more frequently diagnosed with dyslipidemia, as were subjects with lower socio-economic status, educational level, or household income.

Table 3 shows results of our multiple and logistic regression analysis to investigate the association between awareness of nutrition labeling and outcome variables related to dyslipidemia. Individuals with higher awareness of nutrition labeling had lower TG and higher HDL cholesterol levels than those with lower awareness, although we observed some negative associations between awareness and TC and LDL cholesterol levels. Male or older individuals generally had association with high risk levels of four indicators, while individuals with healthy behaviors had association with low risk levels of those. The results of our logistic regression analysis to examine the association between awareness of nutrition labeling and risk of dyslipidemia show that individuals with higher awareness of nutrition labeling had a lower risk of dyslipidemia than individuals who did not. Risk of dyslipidemia was also higher in males, older participants, and individuals with unhealthy behaviors.

We also performed subgroup multiple logistic regression analysis to examine possible associations between nutrition labeling awareness and the risk of dyslipidemia with respect to sex, age, educational level, BMI, subjective health status, and the frequency of eating out. Although the interactions between subgroup variables and labeling awareness were only analyzed for sex and age, we did note positive associations between low risk of dyslipidemia and higher awareness in each group. In general, these positive association were more noticeable in males, younger individuals, those with the low educational level, obese participants, and those with the less than four times a week of eating out (Figs. 1 and 2).

**Discussion**

After 1995, nutrition labeling was mandated by the South Korean government to improve consumer information regarding food purchases. Its expansion since then is expected to positively impact the overall health status in South Korea, especially in patients with certain chronic diseases [10]. Thus, we hypothesized that

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**Fig. 1** The results of subgroup analysis for the multiple logistic regression analysis to examine the association between awareness regarding nutrition labelling and risk of dyslipidemia according to sex, age, and educational level. *Awareness regarding nutrition labelling = A1: checks nutrition facts and makes labeling-dependent purchase decisions, A2: checks nutrition facts but does not make labeling-dependent purchase decisions/aware of nutrition facts but does not check them when making food purchase decisions, and ref = unaware of nutrition facts. The OR is marked as square point; and results were statistically significant if each bar as marked to SD is not reached the cutoff line in 1.00. *UCL = 95 % upper confidence limit, LCL = 95 % lower confidence limit
awareness of nutrition labeling significantly affects diet-related health status, particularly dyslipidemia, and explored possible associations between awareness level and risk of dyslipidemia in individuals not yet diagnosed.

Our findings indicate that a higher awareness level was inversely related to the risk of dyslipidemia, especially with respect to TG and HDL cholesterol indicators [22]. Previous studies have already shown that nutrition labeling is positively associated with patient self-management of chronic diseases, such as the changing of their dietary habits. In addition, introducing nutrition labeling may reduce obesity and promote certain healthy behaviors [10, 23]. However, simply introduction of the labeling cannot be effective without a detailed review of how people perceive and use the system [24]. Therefore, more public health promotion of nutrition labeling should be provided for elderly populations. Differences by sex regarding the impact of nutrition labeling were significant only in males. This is similar to reason due to age, the females had more attention for manage their health and body shape than males. In addition, there were greater impact by higher awareness of nutrition labeling than others. The nutrition labeling system in South Korea was applied into food materials for home cooking as well as meals sold by a restaurant. Based on results, the introduction of food labelling system in South Korea might be helpful in improving the health behavior of South Korean when choose the food materials for home cooking rather than eating out. Also, such results might be caused by differences of attention for health, because the people with less eating out had more attention for manage their and their family's health.

Because nutrition labeling appeared to have a greater impact in individuals with lower educational level, perhaps introduction of the system has improved accessibility of health information for economically vulnerable populations [25]. The impact was also greater in younger individuals, likely due to their general concern regarding diet choices [25].

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**Fig. 2** The results of subgroup analysis for the multiple logistic regression analysis to examine the association between awareness regarding nutrition labelling and risk of dyslipidemia according to BMI, subjective health status, and the frequency of eating out. *Awareness regarding nutrition labelling = A1: checks nutrition facts and makes labeling-dependent purchase decisions, A2: checks nutrition facts but does not make labeling-dependent purchase decisions/aware of nutrition facts but does not check them when making food purchase decisions, and ref = unaware of nutrition facts. The OR is marked as square point; and results were statistically significant if each bar as marked to SD is not reached the cutoff line in 1.00. *UCL = 95 % upper confidence limit, LCL = 95 % lower confidence limit
individuals with poor health, such as those with obesity [13]. These results should motivate health professionals and policymakers to consider the positive effects of nutrition labeling awareness when establishing health policies or programs for specific populations [26]. Moreover, by promoting the advantages of nutrition labeling awareness, we expected that more remarkable improvements of health status in South Korean will be observed.

Our study had several strengths compared with previous studies. First, we used nationwide sampling data during a 5-year period, so our results are helpful in establishing long-term health policy at the national level. Second, to our knowledge, our study is the first to specifically investigate the association between awareness and utilization of nutrition labeling information and the risk of dyslipidemia in South Korean individuals. Third, our results suggest that public perception of new health policies is important for determining their long-term success rather than only shortly after their introduction [24, 27]. Finally, we considered socioeconomic status and health behaviors, such as smoking, alcohol intake, fat intake, and aerobic workout habits, to minimize the effects of confounding variables on our observed results.

However, our study also has limitations. Because the data used in this study were cross-sectional, rather than longitudinal, some concerns about causal relationships between labeling awareness and outcome variables were present. To minimize these concerns, we excluded respondents who were already diagnosed with dyslipidemia and defined dyslipidemia based on their results on the day of investigation. Second, we calculated the respondents’ LDL cholesterol levels using the Friedewald formula because these data were not directly collected as part of our study [28]. The indirect measurement of LDL cholesterol may result in underestimation, so some LDL cholesterol-related results may not be accurate. Finally, the impact of labeling awareness led to some inconsistent trends with some indicators, possibly due to the method of measurement used. Therefore, further studies using data with more detailed measurements are needed.

Despite such limitations, our findings suggest that high awareness and active utilization of nutrition labeling were inversely associated with risk of dyslipidemia, especially in vulnerable populations and younger participants, as they may be more attentive to their health status than others. Based on these results, health policymakers and professionals should consider promoting nutrition labeling awareness as an alternative for managing dyslipidemia in South Korean patients.

Conclusion
The awareness of nutrition labeling had positive outcomes for TG and HDL cholesterol levels related to dyslipidemia.

In addition, the active utilization of nutrition labeling was associated with a low risk of dyslipidemia. Based on our findings, health policymakers and professionals should develop effective alternatives such as promoting the use of nutrition labeling for the management of chronic diseases in South Korea.

Abbreviations
ANOVA: Analysis of variance; BMI: Body mass index; CI: Confidence interval; CVD: Cardiovascular diseases; HDL: High-density lipoprotein; KCDC: Korea Centers for disease control and prevention; KNHANES: Korea National Health and Nutrition Examination Surveys; LDL: Low-density lipoprotein; OR: Odds ratio; SD: Standard deviation; SE: Standard error; TC: Total cholesterol; TG: Triglyceride

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Availability of data and materials
The KNHANES was openly available in https://knhanes.cdc.go.kr/knhanes/eng/index.do after submitting e-mail address and registering short-form information.

Authors’ contributions
JKY, KHK, and MJK designed the study, collected data, performed statistical analyses, and wrote the manuscript. SYJ, ECP, and KTH contributed to the discussion and reviewed and edited the manuscript. KTH is the guarantor of this work and as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. The text in this document has been checked by at least two professional editors who are native English speakers. In addition, WK provided re-editing services for our manuscript to improve quality of scientific writing. All authors read and approved the final manuscript.

Competing interests
The authors declare that they have no competing interests.

Consent for publication
Not applicable.

Ethics approval and consent to participate
These data was approved by the KCDC Institutional Review Board, and all participants provided written informed consent (2010-02CON-21-C, 2011-02CON-06-C, 2012-01-EXP-01-2C, 2013-07CON-03-4C, and 2014-12EXP-03-5C).

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