Association between Use of Nutritional Labeling and the Metabolic Syndrome and Its Components

Hyung-sub Jin¹, Eun-bee Choi¹, Minseo Kim¹, Sarah Soyeon Oh²,³ and Sung-In Jang²,⁴,*

¹ Medical Courses, Yonsei University College of Medicine, Seoul 03722, Korea
² Institute of Health Services Research, Yonsei University, Seoul 03722, Korea
³ Department of Public Health, Graduate School, Yonsei University, Seoul 03722, Korea
⁴ Department of Preventive Medicine, Yonsei University College of Medicine, Seoul 03722, Korea
* Correspondence: jangsi@yuhs.ac; Tel.: +82-2-2228-1863

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Abstract: In this study, we looked into the association between the diagnosis of metabolic syndrome (MetS) and nutritional label awareness. This study used data from the Korea National Health and Nutritional Examination Survey (KNHANES) for the years 2007 to 2015. The study population consisted of a total of 41,667 Koreans of which 11,401 (27.4%) were diagnosed with metabolic syndrome and 30,266 (72.6%) were not. Groups not using nutritional labeling had a 24% increase in odds risk (OR: 1.24, 95% CI 1.14–1.35) of MetS compared to groups using nutritional labeling. Use of nutritional labeling was associated with all components of MetS. Central obesity showed the highest increase in odds risk (OR: 1.23, 95% CI 1.13–1.35) and high blood pressure showed the lowest increase in odds risk (OR: 1.11, 95% CI 1.02–1.20). Subgroup analysis revealed that statistically significant factors were smoking status, drinking status and stress status. Groups that smoke, groups that do not drink and groups with high stress were more vulnerable to MetS when not using nutritional labeling. People not using food labels tends to develop metabolic syndromes more than people using foods labels. In the subgroup analysis, drinking status, smoking status and stress status were significant factors.

Keywords: metabolic syndrome; nutritional labeling; Korea National Health and Nutritional Examination Survey; smoking; drinking; stress

1. Introduction

According to a study by the Korean Statistical Information Service (KOSIS) in 2017, cardiovascular diseases and diabetes were ranked inside the top ten causes of death in Korea [1].

It is widely known that people with metabolic syndrome, which is not a specific disease but a cluster of attributes, including hyperglycemia, insulin resistance, hypertension, and raised VLDL-triglycerides [2], have a higher probability of developing cardiovascular disease and diabetes mellitus, with higher mortality from all causes as well as cardiovascular disease [3–5].

Contracting metabolic syndromes is known to approximately double the risk of cardiovascular disease and quintuple the risk in type 2 diabetes over 5 to 10 years [6]. Therefore, in an attempt to lower the number of deaths caused by these two high-mortality diseases, researches about metabolic syndromes and lifestyle are rapidly being conducted.
Numerous studies suggest a positive correlation between alcohol consumption and metabolic syndrome [7–10]. Most studies analyzing the occurrence of metabolic syndrome and characteristics of humans cover lifestyle and genetic characteristics, such as ethnicity, gender, age, diabetes and obesity [11–15]. However, there are a limited number of researches about the association between metabolic syndrome and nutrition label awareness. The number of studies that relate metabolic syndrome and nutrition label comprehension deal with the U.S. population, not the Korean population [16]. Furthermore, researches analyzing this association using credible research data covering more than five years are not prevalent, with most studies only handling two to three years [17,18]. With a need to analyze the Korean population within a longer time period, our team decided to look into the metabolic syndrome occurrence and nutrition labeling comprehension of the Korean population from 2007 to 2015, a total of nine years.

In this study, we tried to show a relationship between use of nutritional labeling and metabolic syndrome (MetS). We analyzed the association between metabolic syndrome and nutrition label awareness, as well as sex, age, degree of physical activity, occupied area, smoking status, income, occupation and academic level within the year 2007 to 2015. In an effort to resolve the problem that metabolic syndrome is not a clear disease, we used five standards (central obesity, high triglycerides, low HDL cholesterol, high blood pressure and high fasting plasma glucose) to determine the condition’s presence.

2. Materials and Methods

2.1. Study Population and Data

This study was conducted using data from the Korea National Health and Nutrition Examination Survey (KNHANES). KNHANES gives statistic information about the health and nutritional status of the population and select the health-vulnerable groups that need to be prioritized. The survey also provides statistics for health-related policies in Korea, which also serve as the research infrastructure for studies on risk factors and diseases by supporting over 500 publications [19].

The target population of KNHANES comprises non-institutionalized Korean citizens residing in Korea. The sampling plan follows a multi-stage clustered probability design. For example, in the 2011 survey, 192 primary sampling units (PSUs) were drawn from approximately 200,000 geographically defined PSUs for the whole country. A PSU consisted of an average of 60 households, and 20 final target households were sampled for each PSU using systematic sampling; in the selected households, individuals aged 1 year and over were targeted. The number of participants is shown in Table 1. The numbers of participants of the first three surveys (1998, 2001 and 2005) were approximately 35,000 in each survey. From 2007 the survey became a continuous programme with about 10,000 individuals each year except for the year 2007, when the number of participants was half of that of other years as the 2007 survey was conducted during a half-year (from July through December). All the statistics of this survey were calculated using sample weights assigned to sample participants.

The KNHANES is a national surveillance system that has been assessing the health and nutritional status of Koreans since 1998. The survey is based on the National Health Promotion Act, and the surveys have been conducted by the Korea Centers for Disease Control and Prevention (KCDC). Approximately 10,000 individuals were selected from 192 primary sampling units (PSUs) around the country [19].
Table 1. General characteristics of the study observations (2007–2015).

|                          | Metabolic Syndrome |               |               |               |
|--------------------------|--------------------|---------------|---------------|---------------|
|                          | Total              | Yes           | No            |               |
|                          | n                  | (%)           | n             | (%)           |
| Use of Nutritional Labeling | Yes                | 5907          | (14.2)        | 1043          | (17.7)        |
|                          | No                 | 35,760        | (85.8)        | 10,358        | (29.0)        |
|                          |                    |               | 4864          | (82.3)        |
| Age                      | 20–29              | 5336          | (12.8)        | 329           | (6.2)         |
|                          | 30–39              | 8642          | (20.7)        | 1187          | (13.7)        |
|                          | 40–49              | 8416          | (20.2)        | 2003          | (23.8)        |
|                          | 50–59              | 7791          | (18.7)        | 2729          | (35.0)        |
|                          | 60–69              | 6467          | (15.5)        | 2918          | (45.1)        |
|                          | 70–79              | 4211          | (10.1)        | 1919          | (45.6)        |
|                          | ≥80                | 804           | (1.9)         | 316           | (39.3)        |
| Region                   | Urban              | 16,699        | (40.1)        | 4408          | (26.4)        |
|                          | Rural              | 24,968        | (59.9)        | 6993          | (28.0)        |
| Household Income         | Low                | 7292          | (17.5)        | 2860          | (39.2)        |
|                          | Medium-low         | 10,492        | (25.2)        | 3042          | (29.0)        |
|                          | Medium-high        | 11,747        | (28.2)        | 2816          | (24.0)        |
|                          | High               | 12,136        | (29.1)        | 2683          | (22.1)        |
| Occupation               | White Collar       | 14,808        | (35.5)        | 3257          | (22.0)        |
|                          | Sales and Services | 10,890        | (26.1)        | 3317          | (30.5)        |
|                          | Blue Collar        | 15,969        | (38.3)        | 4827          | (30.2)        |
| Educational Attainment   | ≤Elementary School | 9111          | (21.9)        | 4141          | (45.5)        |
|                          | Middle School      | 4539          | (10.9)        | 1597          | (35.2)        |
|                          | High School Diploma| 14,675        | (35.2)        | 3324          | (22.7)        |
|                          | ≥Bachelor’s Degree | 13,342        | (32.0)        | 2339          | (17.5)        |
| Obesity                  | Underweight        | 1882          | (4.5)         | 40            | (2.1)         |
|                          | Normal weight      | 26,583        | (63.8)        | 4304          | (16.2)        |
|                          | Overweight         | 13,202        | (31.7)        | 7057          | (53.5)        |
| Smoking Status           | Non-smoker         | 32,825        | (78.8)        | 8891          | (27.1)        |
|                          | Smoker             | 8842          | (21.2)        | 2510          | (28.4)        |
| Drinking Status          | Non-drinker        | 16,281        | (30.1)        | 4680          | (28.8)        |
|                          | Drinker            | 25,386        | (60.9)        | 6721          | (26.5)        |
| Stress Status            | Low stress         | 30,427        | (73.0)        | 8417          | (27.7)        |
|                          | High stress        | 11,240        | (27.0)        | 2984          | (26.6)        |
| Year                     | 2007               | 2267          | (5.4)         | 698           | (30.8)        |
|                          | 2008               | 5493          | (13.2)        | 1365          | (24.9)        |
|                          | 2009               | 6151          | (14.8)        | 1532          | (24.9)        |
|                          | 2010               | 5120          | (12.3)        | 1258          | (24.6)        |
|                          | 2011               | 5032          | (12.1)        | 1246          | (24.8)        |
|                          | 2012               | 4621          | (11.1)        | 1203          | (26.0)        |
|                          | 2013               | 4502          | (10.8)        | 1140          | (25.5)        |
|                          | 2014               | 4208          | (10.1)        | 1101          | (26.2)        |
|                          | 2015               | 4273          | (10.3)        | 1858          | (43.5)        |
|                          | Total              | 41,667        | (100.0)       | 11,401        | (100.0)       |
|                          |                    | 30,266        | (100.0)       |               |               |
2.2. Variables

In this study, metabolic syndrome (MetS) and its components were selected as the outcome variable. The presence of MetS was measured using the guidelines provided by the Korean Academy of Medical Sciences. According to the Korean Academy of Medical Sciences, those with MetS have three of the following five features: (1) centrally obese (measured by a waist circumference of ≥90 cm if male and ≥80 cm if female); (2) an increased triglyceride level of ≥150 mg/dL; (3) a decreased high density lipoprotein cholesterol level of <40 mg/dL in men and <50 mg/dL in women; (4) raised blood pressure, indicated by a systolic blood pressure of ≥130 mmHg, or a diastolic blood pressure of ≥85 mmHg, or treatment of previously diagnosed hypertension; and (5) an increased fasting plasma glucose level of ≥100 mg/dL. Such components, as well as all health-related components of the KNHANES, were collected via standardized physical examination by medical technicians serving as staff members for the survey.

Use of nutritional labeling when choosing the food was surveyed by KNHANES and was categorized into the following two groups: (1) Yes and (2) No.

Various demographic, socioeconomic and health-related covariates were included. Covariates included sex (male, female), age (20–29, 30–39, 40–49, 50–59, 60–69, 70–79, ≥80), region (urban, rural), household income group (low, medium-low, medium-high, high), occupation (white collar, sales and services, blue collar), educational attainment (≤elementary school, middle school, high school diploma, ≥bachelor’s degree), obesity (underweight, normal weight, overweight), smoking status (non-smoker, smoker), drinking status (non-drinker, drinker) and stress status (low stress, high stress). Income groups were obtained by dividing household income by the square root of the number of household members and divided it into four groups using quartiles. These variables are profound factors for MetS, and we controlled these variables in our study.

2.3. Statistical Analysis

To examine the association between the use of nutritional labeling and MetS and its components, multiple logistic regression analysis was performed using the data. Odds ratios and 95% confidence intervals (CIs) were calculated to compare between the using nutritional labeling group and the non-using nutritional labeling group.

Our study population consisted of 19,368 Korean males and 22,299 Korean females over 20 years of age from 2007 to 2015. There were no missing subjects from the initial population. All analyses were performed using SAS software, version 9.4 (SAS Institute, Cary, NC, USA).

3. Results

3.1. Study Participants

Tables 1 and 2 present the results for the general characteristics of the 41,667 Koreans above the age of 20, from 2007 to 2015, within our final study population. A total of 11,401 (27.4%) were diagnosed with MetS and 30,266 (72.6%) were not. A total of 5907 (14.2%) used nutritional labeling when choosing the food and 35,760 (85.8%) did not.
Table 2. General Characteristics of Study Observations of Metabolic Syndrome’s components (2007–2015).

| Smoking Status | Bachelor's (n) | Master's (n) | PhD (n) | Total Yes | Total No | Total Yes | Total No | Total Yes | Total No | Total Yes | Total No | Total Yes | Total No | Total Yes | Total Yes | Total No | Total Yes | Total No | Total Yes | Total No |
|----------------|---------------|--------------|---------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Yes            | 5907          | 14.2         | 1704     | 28.9      | 4203      | 71.2      | 5907      | 14.2      | 2214      | 39.2      | 3593      | 60.8      | 5907      | 14.2      | 1336      | 22.6      | 4571      | 77.4      | 5907      | 14.2      | 1061     | 18.0      | 4846      | 82.0      |
| No             | 35,760        | 85.8         | 12,701   | 35.5      | 23,095     | 64.5      | 35,760    | 85.8      | 10,332     | 29.0      | 25,408     | 71.1      | 35,760    | 85.8      | 14,405     | 40.3      | 21,355     | 57.7      | 35,760    | 85.8      | 10,416    | 29.1      | 25,344     | 70.9      |

**Education**

| Sex            | Total | Yes (%) | No (%) | Total | Yes (%) | No (%) | Total | Yes (%) | No (%) | Total | Yes (%) | No (%) | Total | Yes (%) | No (%) | Total | Yes (%) | No (%) | Total | Yes (%) | No (%) |
|----------------|-------|---------|--------|-------|---------|--------|-------|---------|--------|-------|---------|--------|-------|---------|--------|-------|---------|--------|-------|---------|--------|
| Male           | 19,368 | 46.5    | 5260    | 27.2   | 14,108   | 72.8   | 19,368 | 46.5    | 7069    | 36.5   | 12,299   | 63.5   | 19,368 | 46.5    | 6502    | 33.6   | 12,866   | 64.4   | 19,368 | 46.5    | 8993    | 46.4   |
| Female         | 22,289 | 53.5    | 9145    | 41.0   | 13,154   | 59.0   | 22,289 | 53.5    | 12,427   | 19.9   | 17,987   | 82.2   | 22,289 | 53.5    | 10,217   | 45.8   | 12,082   | 54.2   | 22,289 | 53.5    | 6772    | 30.3   |

**Sex**

| Smoking Status | Smoking Status | Bachelor's (n) | Master's (n) | PhD (n) | Total Yes | Total No | Total Yes | Total No | Total Yes | Total No | Total Yes | Total No | Total Yes | Total No | Total Yes | Total Yes | Total Yes | Total Yes | Total Yes | Total Yes |
|----------------|----------------|---------------|--------------|---------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Yes            | 5907          | 14.2          | 1704         | 28.9    | 4203      | 71.2      | 5907      | 14.2      | 2214      | 39.2      | 3593      | 60.8      | 5907      | 14.2      | 1336      | 22.6      | 4571      | 77.4      | 5907      | 14.2      | 1061     | 18.0      | 4846      | 82.0      |
| No             | 35,760        | 85.8          | 12,701       | 35.5    | 23,095     | 64.5      | 35,760    | 85.8      | 10,332     | 29.0      | 25,408     | 71.1      | 35,760    | 85.8      | 14,405     | 40.3      | 21,355     | 57.7      | 35,760    | 85.8      | 10,416    | 29.1      | 25,344     | 70.9      |

**Smoking Status**

| Smoking Status | Bachelor's (n) | Master's (n) | PhD (n) | Total Yes | Total No | Total Yes | Total No | Total Yes | Total No | Total Yes | Total No | Total Yes | Total No | Total Yes | Total Yes | Total Yes | Total Yes | Total Yes | Total Yes | Total Yes |
|----------------|---------------|--------------|---------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Yes            | 5907          | 14.2          | 1704       | 28.9     | 4203      | 71.2      | 5907      | 14.2      | 2214      | 39.2      | 3593      | 60.8      | 5907      | 14.2      | 1336      | 22.6      | 4571      | 77.4      | 5907      | 14.2      | 1061     | 18.0      | 4846      | 82.0      |
| No             | 35,760        | 85.8          | 12,701     | 35.5     | 23,095     | 64.5      | 35,760    | 85.8      | 10,332     | 29.0      | 25,408     | 71.1      | 35,760    | 85.8      | 14,405     | 40.3      | 21,355     | 57.7      | 35,760    | 85.8      | 10,416    | 29.1      | 25,344     | 70.9      |
Table 2. Cont.

| Central Obesity | High Triglycerides | Low HDL Cholesterol | High Blood Pressure | High Fasting Plasma Glucose |
|-----------------|--------------------|---------------------|--------------------|-----------------------------|
| **Drinking Status** |                    |                     |                    |                             |
| Non-drinker     | 16,281 (30.1)      | 6377 (39.2)         | 9904 (60.8)        | 16,281 (30.1)               |
|                  | 3822 (23.5)        | 12,459 (76.5)       | 7922 (48.7)        | 8359 (51.3)                 |
| Drinker         | 25,386 (60.9)      | 8028 (31.6)         | 17,358 (68.4)      | 25,386 (60.9)               |
|                  | 7674 (30.2)        | 7,172 (69.8)        | 8797 (34.7)        | 16,589 (65.4)               |
| **Stress Status** |                    |                     |                    |                             |
| Low stress      | 30,427 (73.0)      | 10,442 (34.3)       | 19,985 (65.7)      | 30,427 (73.0)               |
|                  | 11,240 (27.0)      | 3963 (35.3)         | 7,227 (64.7)       | 11,240 (27.0)               |
| High stress     | 11,240 (27.0)      | 3963 (35.3)         | 7,227 (64.7)       | 11,240 (27.0)               |
| **Year**        |                    |                     |                    |                             |
| 2007            | 2,287 (5.4)        | 543 (2.4)           | 867 (38.2)         | 1,400 (5.4)                 |
| 2008            | 2,287 (5.4)        | 543 (2.4)           | 867 (38.2)         | 1,400 (5.4)                 |
| 2009            | 2,287 (5.4)        | 543 (2.4)           | 867 (38.2)         | 1,400 (5.4)                 |
| 2010            | 2,287 (5.4)        | 543 (2.4)           | 867 (38.2)         | 1,400 (5.4)                 |
| 2011            | 2,287 (5.4)        | 543 (2.4)           | 867 (38.2)         | 1,400 (5.4)                 |
| 2012            | 2,287 (5.4)        | 543 (2.4)           | 867 (38.2)         | 1,400 (5.4)                 |
| 2013            | 2,287 (5.4)        | 543 (2.4)           | 867 (38.2)         | 1,400 (5.4)                 |
| 2014            | 2,287 (5.4)        | 543 (2.4)           | 867 (38.2)         | 1,400 (5.4)                 |
| 2015            | 2,287 (5.4)        | 543 (2.4)           | 867 (38.2)         | 1,400 (5.4)                 |
| **Total**       | 41,667 (100.0)     | 14,405 (100.0)      | 27,262 (100.0)     | 41,667 (100.0)              |

| Drinking Status | Yes (%) | No (%) | Yes (%) | No (%) | Yes (%) | No (%) | Yes (%) | No (%) | Yes (%) | No (%) | Yes (%) | No (%) | Yes (%) | No (%) |
|-----------------|---------|--------|---------|--------|---------|--------|---------|--------|---------|--------|---------|--------|---------|--------|
| Non-drinker     | 30.1    | 69.9   | 60.8    | 39.2   | 60.8    | 39.2   | 60.8    | 39.2   | 60.8    | 39.2   | 60.8    | 39.2   | 60.8    | 39.2   |
| Drinker         | 60.9    | 39.1   | 39.2    | 60.8   | 39.2    | 60.8   | 39.2    | 60.8   | 39.2    | 60.8   | 39.2    | 60.8   | 39.2    | 60.8   |
| **Stress Status** |        |        |         |        |         |        |         |        |         |        |         |        |         |        |
| Low stress      | 73.0    | 27.0   | 33.3    | 66.7   | 40.7    | 59.3   | 40.7    | 59.3   | 40.7    | 59.3   | 40.7    | 59.3   | 40.7    | 59.3   |
| High stress     | 27.0    | 73.0   | 33.3    | 66.7   | 40.7    | 59.3   | 40.7    | 59.3   | 40.7    | 59.3   | 40.7    | 59.3   | 40.7    | 59.3   |
| **Year**        |         |        |         |        |         |        |         |        |         |        |         |        |         |        |
| 2007            | 5.4     | 94.6   | 61.8    | 38.2   | 1400    | 5.4    | 94.6    | 61.8   | 38.2    | 1400    | 5.4    | 94.6    | 61.8   | 38.2    | 1400    |
| 2008            | 5.4     | 94.6   | 61.8    | 38.2   | 1400    | 5.4    | 94.6    | 61.8   | 38.2    | 1400    | 5.4    | 94.6    | 61.8   | 38.2    | 1400    |
| 2009            | 5.4     | 94.6   | 61.8    | 38.2   | 1400    | 5.4    | 94.6    | 61.8   | 38.2    | 1400    | 5.4    | 94.6    | 61.8   | 38.2    | 1400    |
| 2010            | 5.4     | 94.6   | 61.8    | 38.2   | 1400    | 5.4    | 94.6    | 61.8   | 38.2    | 1400    | 5.4    | 94.6    | 61.8   | 38.2    | 1400    |
| 2011            | 5.4     | 94.6   | 61.8    | 38.2   | 1400    | 5.4    | 94.6    | 61.8   | 38.2    | 1400    | 5.4    | 94.6    | 61.8   | 38.2    | 1400    |
| 2012            | 5.4     | 94.6   | 61.8    | 38.2   | 1400    | 5.4    | 94.6    | 61.8   | 38.2    | 1400    | 5.4    | 94.6    | 61.8   | 38.2    | 1400    |
| 2013            | 5.4     | 94.6   | 61.8    | 38.2   | 1400    | 5.4    | 94.6    | 61.8   | 38.2    | 1400    | 5.4    | 94.6    | 61.8   | 38.2    | 1400    |
| 2014            | 5.4     | 94.6   | 61.8    | 38.2   | 1400    | 5.4    | 94.6    | 61.8   | 38.2    | 1400    | 5.4    | 94.6    | 61.8   | 38.2    | 1400    |
| 2015            | 5.4     | 94.6   | 61.8    | 38.2   | 1400    | 5.4    | 94.6    | 61.8   | 38.2    | 1400    | 5.4    | 94.6    | 61.8   | 38.2    | 1400    |
| **Total**       | 5.4     | 94.6   | 61.8    | 38.2   | 1400    | 5.4    | 94.6    | 61.8   | 38.2    | 1400    | 5.4    | 94.6    | 61.8   | 38.2    | 1400    |
Among the 5907 people who used nutritional labeling, 1043 (17.7%) were diagnosed with MetS and 4864 (82.3%) were not. For the 35,760 people who also did not use nutritional labeling 10,358 (29.0%) were diagnosed with MetS and 25,402 (71.0%) were not.

3.2. Relationship between MetS and Use of Nutritional Labeling

Table 3 presents the results of multiple logistic regression analysis of the study population for MetS adjusted for the following variables: use of nutritional labeling, sex, age, region, household income, occupation, educational attainment, obesity, smoking status, drinking status and stress status. Table 4 presents the results of multiple logistic regression analysis of the study population for casual components of MetS adjusted for the same variables in Table 3.

Groups not using the nutritional labeling had a 24% increase in odds risk (OR: 1.24, 95% CI 1.14–1.35) of MetS compared to groups using the nutritional labeling. As the people got older, the odds risk of MetS also increased. Groups that smoke (OR: 1.36, 95% CI 1.27–1.46) and groups with high stress (OR: 1.10, 95% CI 1.04–1.17) also had a higher odds risk of MetS (Table 3). Groups not using the nutritional labeling showed an increase in odds risk compared to groups using the nutritional labeling for the five components of MetS. Central obesity showed the highest increase in odds risk (OR: 1.23, 95% CI 1.13–1.35) and high blood pressure showed the lowest increase in odds risk (OR: 1.11, 95% CI 1.02–1.20) when not using the nutritional labeling (Table 4).

3.3. Subgroup Analysis

Tables 5 and 6 present the subgroup analysis of the study population. Performing subgroup analysis, the statistically significant factors were smoking status, drinking status and stress status. Groups that smoke (OR: 1.39, 95% CI 1.11–1.75) are more vulnerable to MetS when not using the nutritional labeling compared to non-smoking groups (OR: 1.17, 95% CI 1.07–1.29) (Table 5). Non-drinking groups (OR: 1.23, 95% CI 1.10–1.39) are more vulnerable to MetS than drinking groups (OR: 1.19, 95% CI 1.04–1.36) when not using the nutritional labeling. Finally, high stress groups (OR: 1.32, 95% CI 1.11–1.56) are more vulnerable to MetS than low stress groups (OR: 1.21, 95% CI 1.09–1.34) when not using the nutritional labeling.
| Table 3. Factors associated with metabolic syndrome (2007–2015). |  
|-----------------------------------------------|------------------|-----------------|
| **Use of Nutritional Labeling**               | **Odds Ratio**   | **95% CI ***    |
| Yes                                          | 1.00             | -               |
| No                                           | 1.24 (1.14 – 1.35)|                 |
| **Sex**                                       |                  |                 |
| Male                                         | 1.00             | -               |
| Female                                       | 0.98 (0.92 – 1.04)|                 |
| **Age**                                       |                  |                 |
| 20–29                                        | 1.00             | -               |
| 30–39                                        | 2.36 (2.07 – 2.71)|                 |
| 40–49                                        | 4.41 (3.86 – 5.02)|                 |
| 50–59                                        | 7.00 (6.13 – 8.00)|                 |
| 60–69                                        | 10.44 (9.08 – 12.00)|               |
| 70–79                                        | 11.27 (9.69 – 13.11)|               |
| ≥80                                          | 10.21 (8.26 – 12.61)|               |
| **Region**                                    |                  |                 |
| Urban                                        | 1.00             | -               |
| Rural                                        | 1.00 (0.95 – 1.05)|                 |
| **Household Income**                          |                  |                 |
| Low                                          | 1.00             | -               |
| Medium-low                                   | 0.95 (0.88 – 1.03)|                 |
| Medium-high                                  | 0.93 (0.85 – 1.01)|                 |
| High                                         | 0.88 (0.81 – 0.96)|                 |
| **Occupation**                                |                  |                 |
| White Collar                                 | 1.00             | -               |
| Sales and Services                           | 0.80 (0.74 – 0.86)|                 |
| Blue Collar                                  | 1.07 (0.99 – 1.14)|                 |
| **Educational Attainment**                    |                  |                 |
| ≤Elementary School                           | 1.00             | -               |
| Middle School                                | 0.77 (0.70 – 0.84)|                 |
| High School Diploma                          | 0.71 (0.65 – 0.77)|                 |
| ≥Bachelor’s Degree                           | 0.60 (0.54 – 0.66)|                 |
| **Obesity**                                   |                  |                 |
| Underweight                                  | 0.13 (0.10 – 0.18)|                 |
| Normal weight                                | 1.00             | -               |
| Overweight                                   | 6.73 (6.39 – 7.09)|                 |
| **Smoking Status**                            |                  |                 |
| Non-smoker                                   | 1.00             | -               |
| Smoker                                       | 1.36 (1.27 – 1.46)|                 |
| **Drinking Status**                           |                  |                 |
| Non-drinker                                  | 1.00             | -               |
| Drinker                                      | 1.05 (0.99 – 1.11)|                 |
| **Stress Status**                             |                  |                 |
| Low stress                                   | 1.00             | -               |
| High stress                                  | 1.10 (1.04 – 1.17)|                 |
| **Year**                                      |                  |                 |
| 2007                                         | 1.00             | -               |
| 2008                                         | 0.70 (0.62 – 0.80)|                 |
| 2009                                         | 0.70 (0.62 – 0.79)|                 |
| 2010                                         | 0.71 (0.62 – 0.81)|                 |
| 2011                                         | 0.66 (0.58 – 0.76)|                 |
| 2012                                         | 0.72 (0.63 – 0.82)|                 |
| 2013                                         | 0.72 (0.63 – 0.82)|                 |
| 2014                                         | 0.74 (0.65 – 0.84)|                 |
| 2015                                         | 1.98 (1.74 – 2.25)|                 |

* CI: Confidence interval. The bolds here are to show that they are the significant variables.
Table 4. Factors associated with the casual factors of metabolic syndrome’s components (2007–2015).

|                    | Central Obesity | High Triglycerides | Low HDL Cholesterol | High Blood Pressure | High Fasting Plasma Glucose |
|--------------------|-----------------|--------------------|----------------------|---------------------|-----------------------------|
|                    | Odds Ratio      | 95% CI *           | Odds Ratio           | 95% CI *            | Odds Ratio                  | 95% CI *                  |
| Use of Nutritional Labeling |                 |                    |                      |                     |                             |                          |
| Yes                | 1.00            | -                  | 1.00                 | -                   | 1.00                        | -                         |
| No                 | 1.23 (1.13 – 1.35) | 1.15 (1.07 – 1.25) | 1.21 (1.12 – 1.30) | 1.11 (1.02 – 1.20) | 1.13 (1.04 – 1.22)         |
| Sex                |                 |                    |                      |                     |                             |                          |
| Male               | 1.00            | -                  | 1.00                 | -                   | 1.00                        | -                         |
| Female             | 5.06 (4.69 – 5.45) | 0.52 (0.49 – 0.55) | 1.95 (1.84 – 2.06) | 0.51 (0.48 – 0.54) | 0.56 (0.53 – 0.59)         |
| Age                |                 |                    |                      |                     |                             |                          |
| 20–29              | 1.00            | -                  | 1.00                 | -                   | 1.00                        | -                         |
| 30–39              | 1.56 (1.40 – 1.74) | 1.82 (1.65 – 2.00) | 1.31 (1.20 – 1.43) | 1.70 (1.52 – 1.90) | 2.80 (2.45 – 3.20)         |
| 40–49              | 1.81 (1.62 – 2.02) | 2.53 (2.29 – 2.78) | 1.41 (1.29 – 1.54) | 3.69 (3.32 – 4.11) | 5.39 (4.74 – 6.13)         |
| 50–59              | 2.64 (2.36 – 2.97) | 2.87 (2.59 – 3.17) | 1.35 (1.23 – 1.48) | 7.07 (6.34 – 7.88) | 8.67 (7.61 – 9.87)         |
| 60–69              | 4.30 (3.78 – 4.88) | 2.57 (2.31 – 2.87) | 1.67 (1.51 – 1.85) | 11.57 (10.31 – 12.98) | 11.01 (9.61 – 12.60)       |
| 70–79              | 4.95 (4.28 – 5.73) | 1.96 (1.74 – 2.22) | 1.94 (1.73 – 2.18) | 16.90 (14.86 – 19.23) | 9.72 (8.41 – 11.24)        |
| ≥80                | 3.89 (3.10 – 4.87) | 1.25 (1.01 – 1.54) | 4.42 (3.66 – 5.34) | 22.94 (18.79 – 28.02) | 6.35 (5.16 – 7.81)         |
| Region             |                 |                    |                      |                     |                             |                          |
| Urban              | 1.00            | -                  | 1.00                 | -                   | 1.00                        | -                         |
| Rural              | 1.11 (1.05 – 1.18) | 1.04 (0.99 – 1.09) | 1.08 (1.03 – 1.13) | 0.92 (0.88 – 0.97) | 1.02 (0.98 – 1.08)         |
| Household Income   |                 |                    |                      |                     |                             |                          |
| Low                | 1.00            | -                  | 1.00                 | -                   | 1.00                        | -                         |
| Medium-low         | 1.02 (0.93 – 1.11) | 0.93 (0.87 – 1.00) | 0.95 (0.88 – 1.02) | 0.91 (0.85 – 0.98) | 1.02 (0.94 – 1.09)         |
| Medium-high        | 0.97 (0.88 – 1.06) | 0.96 (0.89 – 1.04) | 0.94 (0.87 – 1.01) | 0.91 (0.84 – 0.98) | 1.03 (0.95 – 1.11)         |
| High               | 0.93 (0.84 – 1.02) | 0.94 (0.87 – 1.02) | 0.89 (0.82 – 0.96) | 0.83 (0.77 – 0.90) | 0.99 (0.91 – 1.07)         |
| Occupation         |                 |                    |                      |                     |                             |                          |
| White Collar       | 1.00            | -                  | 1.00                 | -                   | 1.00                        | -                         |
| Sales and Services | 0.89 (0.83 – 0.97) | 0.84 (0.78 – 0.89) | 0.83 (0.78 – 0.89) | 0.94 (0.88 – 1.00) | 0.94 (0.88 – 1.00)         |
| Blue Collar        | 1.12 (1.05 – 1.21) | 1.04 (0.97 – 1.10) | 1.08 (1.02 – 1.15) | 1.05 (0.98 – 1.11) | 1.01 (0.94 – 1.08)         |
| Educational Attainment |             |                    |                      |                     |                             |                          |
| ≤Elementary School | 1.00            | -                  | 1.00                 | -                   | 1.00                        | -                         |
| Middle School      | 0.80 (0.72 – 0.88) | 0.81 (0.74 – 0.88) | 0.96 (0.88 – 1.05) | 0.75 (0.69 – 0.81) | 0.95 (0.88 – 1.03)         |
| High School Diploma| 0.70 (0.63 – 0.76) | 0.74 (0.68 – 0.79) | 0.85 (0.79 – 0.92) | 0.71 (0.66 – 0.76) | 0.94 (0.87 – 1.01)         |
| ≥Bachelor’s Degree | 0.66 (0.59 – 0.73) | 0.69 (0.63 – 0.75) | 0.78 (0.71 – 0.85) | 0.60 (0.55 – 0.66) | 0.78 (0.71 – 0.85)         |
Table 4. Cont.

| Smoking Status | Central Obesity | High Triglycerides | Low HDL Cholesterol | High Blood Pressure | High Fasting Plasma Glucose |
|----------------|-----------------|--------------------|---------------------|---------------------|----------------------------|
|                | Odds Ratio & 95% CI * | Odds Ratio & 95% CI * | Odds Ratio & 95% CI * | Odds Ratio & 95% CI * | Odds Ratio & 95% CI * |
| Non-smoker     | 1.00 - - 1.00 - - | 1.00 - - 1.00 - - | 1.00 - - 1.00 - - | 1.00 - - 1.00 - - | 1.00 - - 1.00 - - |
| Smoker         | 1.13 (1.04 – 1.22) | 1.66 (1.56 – 1.76) | 1.30 (1.22 – 1.39) | 0.96 (0.90 – 1.02) | 1.02 (0.96 – 1.09) |
| Drinking Status| Non-drinker      | 1.00 - - 1.00 - - | 1.00 - - 1.00 - - | 1.00 - - 1.00 - - | 1.00 - - 1.00 - - |
|                | Drinker          | 1.01 (0.95 – 1.08) | 1.14 (1.09 – 1.20) | 0.61 (0.59 – 0.65) | 1.23 (1.17 – 1.30) |
| Stress Status  | Low stress       | 1.00 - - 1.00 - - | 1.00 - - 1.00 - - | 1.00 - - 1.00 - - | 1.00 - - 1.00 - - |
|                | High stress      | 1.06 (1.00 – 1.13) | 1.07 (1.01 – 1.13) | 1.04 (0.98 – 1.09) | 1.06 (1.01 – 1.12) |
| Year           | 2007             | 1.00 - - 1.00 - - | 1.00 - - 1.00 - - | 1.00 - - 1.00 - - | 1.00 - - 1.00 - - |
|                | 2008             | 0.89 (0.78 – 1.02) | 0.93 (0.83 – 1.05) | 0.24 (0.21 – 0.26) | 1.11 (0.98 – 1.25) |
|                | 2009             | 0.71 (0.62 – 0.81) | 0.90 (0.80 – 1.01) | 0.22 (0.20 – 0.25) | 1.66 (1.48 – 1.87) |
|                | 2010             | 0.67 (0.58 – 0.77) | 0.90 (0.80 – 1.01) | 0.22 (0.20 – 0.25) | 1.76 (1.56 – 1.99) |
|                | 2011             | 0.77 (0.67 – 0.88) | 0.95 (0.84 – 1.06) | 0.19 (0.17 – 0.21) | 1.46 (1.30 – 1.65) |
|                | 2012             | 0.66 (0.57 – 0.76) | 0.92 (0.82 – 1.03) | 0.25 (0.23 – 0.28) | 1.42 (1.25 – 1.61) |
|                | 2013             | 0.57 (0.49 – 0.66) | 0.91 (0.81 – 1.03) | 0.24 (0.22 – 0.27) | 1.33 (1.17 – 1.50) |
|                | 2014             | 0.69 (0.60 – 0.79) | 0.96 (0.85 – 1.08) | 0.23 (0.21 – 0.26) | 1.28 (1.13 – 1.46) |
|                | 2015             | 0.93 (0.81 – 1.08) | 0.95 (0.85 – 1.08) | 0.23 (0.21 – 0.26) | 1.41 (1.25 – 1.60) |

* CI: Confidence interval. The bolds here are to show that they are the significant variables.
Table 5. Subgroup analysis.

| Use of Labelling | Metabolic Syndrome |
|------------------|--------------------|
|                  | OR |  95% CI |     |
|                  | Lower | Upper |
| Sex              |       |       |
| Male             | 1.00  | 1.13  | 0.98 | 1.31 |
| Female           | 1.00  | 1.10  | 0.98 | 1.23 |
| Age              |       |       |
| 20–29            | 1.00  | 1.35  | 0.95 | 1.91 |
| 30–39            | 1.00  | 1.16  | 0.95 | 1.42 |
| 40–49            | 1.00  | 1.04  | 0.88 | 1.23 |
| 50–59            | 1.00  | 1.15  | 0.96 | 1.37 |
| 60–69            | 1.00  | 1.21  | 0.95 | 1.54 |
| 70–79            | 1.00  | 1.65  | 1.05 | 2.60 |
| ≥80              | 1.00  | 0.13  |     | 9.74 |
| Region           |       |       |
| Urban            | 1.00  | 1.11  | 0.97 | 1.27 |
| Rural            | 1.00  | 1.34  | 1.19 | 1.50 |
| Income (%)       |       |       |
| Low              | 1.00  | 1.20  | 0.91 | 1.58 |
| Medium-low       | 1.00  | 1.33  | 1.12 | 1.59 |
| Medium-high      | 1.00  | 1.11  | 0.95 | 1.29 |
| High             | 1.00  | 1.19  | 1.02 | 1.39 |
| Occupation       |       |       |
| White Collar     | 1.00  | 1.15  | 1.00 | 1.32 |
| Sales and Services | 1.00 | 1.18  | 0.97 | 1.44 |
| Blue Collar      | 1.00  | 1.21  | 1.05 | 1.40 |
| Educational Attainment | |       |
| ≤Elementary School | 1.00 | 1.10  | 0.97 | 1.26 |
| Middle School    | 1.00  | 1.12  | 0.99 | 1.28 |
| High School Diploma | 1.00 | 1.20  | 1.05 | 1.38 |
| ≥Bachelor’s Degree | 1.00 | 0.97  | 0.71 | 1.31 |
Table 5. Cont.

| Use of Labelling | Metabolic Syndrome | 95% CI |
|------------------|--------------------|-------|
|                  | OR | Lower | Upper |
| **Obesity**      |    |       |       |
| Underweight      | 1.00 | 2.06 | 0.41 | 10.39 |
| Normal weight    | 1.00 | 1.46 | 1.28 | 1.68  |
| Overweight       | 1.00 | 1.09 | 0.97 | 1.23  |
| **Smoking Status** |    |       |       |
| Non-smoker       | 1.00 | 1.17 | 1.07 | 1.29  |
| Smoker           | 1.00 | 1.39 | 1.11 | 1.75  |
| **Drinking Status** |    |       |       |
| Non-drinker      | 1.00 | 1.23 | 1.10 | 1.39  |
| Drinker          | 1.00 | 1.19 | 1.04 | 1.36  |
| **Stress Status** |    |       |       |
| Low stress       | 1.00 | 1.21 | 1.09 | 1.34  |
| High stress      | 1.00 | 1.32 | 1.11 | 1.56  |

The bolds here are to show that they are the significant variables.
## Table 6. Subgroup analysis of metabolic syndrome’s components.

| Use of | Central Obesity Use of | High Triglycerides Use of | Low HDL Cholesterol Use of | High Blood Pressure Use of | High Fasting Plasma Glucose Use of |
|--------|------------------------|---------------------------|-----------------------------|-----------------------------|-----------------------------------|
|        | Labeling               | Labeling                  | Labeling                    | Labeling                    | Labeling                          |
|        | OR                     | 95% CI                     | OR                          | 95% CI                      | OR                                | 95% CI |
|        | Lower                  | Upper                      | Lower                       | Upper                       | Lower                             | Upper |
| Sex    |                        |                            |                             |                             |                                   |       |
| Male   | 1.00                   | 1.08                      | 0.92                        | 1.27                        | 1.00                              | 1.07  |
| Female | 1.00                   | 1.20                      | 1.08                        | 1.34                        | 1.00                              | 1.07  |
| Age    |                        |                            |                             |                             |                                   |       |
| 20–29  | 1.00                   | 1.30                      | 1.00                        | 1.70                        | 1.00                              | 1.20  |
| 30–39  | 1.00                   | 1.23                      | 1.03                        | 1.46                        | 1.00                              | 1.23  |
| 40–49  | 1.00                   | 1.06                      | 0.89                        | 1.26                        | 1.00                              | 1.21  |
| 50–59  | 1.00                   | 1.32                      | 1.08                        | 1.60                        | 1.00                              | 1.15  |
| 60–69  | 1.00                   | 1.24                      | 0.93                        | 1.64                        | 1.00                              | 1.23  |
| ≥70    | 1.00                   | 1.33                      | 0.76                        | 2.33                        | 1.00                              | 1.42  |
| Region |                        |                            |                             |                             |                                   |       |
| Urban  | 1.00                   | 1.11                      | 0.97                        | 1.27                        | 1.00                              | 1.11  |
| Rural  | 1.00                   | 1.32                      | 1.18                        | 1.49                        | 1.00                              | 1.22  |
| Income (%) |                    |                            |                             |                             |                                   |       |
| Low    | 1.00                   | 1.28                      | 0.94                        | 1.75                        | 1.00                              | 1.20  |
| Medium-low |                  |                            |                             |                             |                                   |       |
| Medium-high |                  |                            |                             |                             |                                   |       |
| High   | 1.00                   | 1.20                      | 1.03                        | 1.40                        | 1.00                              | 1.17  |
| Occupation |                    |                            |                             |                             |                                   |       |
| White Collar |                |                            |                             |                             |                                   |       |
| Sales and Services |              |                            |                             |                             |                                   |       |
| Blue Collar |                |                            |                             |                             |                                   |       |
| Educational Attainment |             |                            |                             |                             |                                   |       |
| ≤Elementary School |              |                            |                             |                             |                                   |       |
| Middle School |                |                            |                             |                             |                                   |       |
| High School |                |                            |                             |                             |                                   |       |
| Diploma | 1.00                   | 1.21                      | 1.05                        | 1.39                        | 1.00                              | 1.14  |
| ≥Bachelor’s Degree |            |                            |                             |                             |                                   |       |
| Obesity |                        |                            |                             |                             |                                   |       |
| Underweight |                |                            |                             |                             |                                   |       |
| Normal weight |               |                            |                             |                             |                                   |       |
| Overweight |                |                            |                             |                             |                                   |       |
| Smoking Status |                |                            |                             |                             |                                   |       |
| Non-smoker |                |                            |                             |                             |                                   |       |
| Smoker | 1.00                   | 1.25                      | 0.97                        | 1.60                        | 1.00                              | 1.21  |
| Drinking Status |                |                            |                             |                             |                                   |       |
| Non-drinker |                |                            |                             |                             |                                   |       |
| Drinker | 1.00                   | 1.23                      | 1.09                        | 1.38                        | 1.00                              | 1.12  |
| Stress Status |                |                            |                             |                             |                                   |       |
| Low stress |                |                            |                             |                             |                                   |       |
| High stress |                |                            |                             |                             |                                   |       |

The bolds here are to show that they are the significant variables.
4. Discussion

We found that the use of nutritional labeling is associated with metabolic syndrome across the whole observation. We also found that the use of nutritional labeling is associated with decreased metabolic syndrome in the subgroups divided by smoking status, drinking status and stress status. However, in most of the groups divided by other variations, there was no consistent effect of the use of nutritional labeling on metabolic syndrome.

There are numerous previous studies regarding the use of food labels among adults with metabolic syndrome. One study shows that patients with metabolic syndrome tends to use food labels less than adults with no metabolic syndrome [20]. This issue is noteworthy because diet is one of the important ways to treat metabolic syndrome. Especially diets limiting intake of saturated fat and with high fiber/low glycemic-index is an effective treatment for metabolic syndrome [21]. Through our research about the relationship between the use of food labeling and the use of food labeling, the signs are that the use of food labeling is not only necessary for patients with metabolic syndrome but also not using food labels might be one of the causes of metabolic syndrome because diet and metabolic syndrome are closely related. Especially there are significant association between intake of fat and cholesterol and metabolic syndrome in men and intake of carbohydrate and metabolic syndrome in women [22]. In addition, there was research showing that the use of food labels affects intake of nutrients, including total fat, total energy, saturated fat, cholesterol, sodium, dietary fiber and sugars, in a healthier way in the US [16].

There are several limitations of this research. First, there might be other confounders that must be considered because the use of labels was found to be associated with several factors, such as sex, age and socioeconomic status [20]. Therefore, the use of food labels might not be a direct cause of metabolic syndrome and the odds ratio of people not using food labels developing metabolic syndrome might be overrated. It is also impossible to measure the effects of using food labels on developing metabolic syndrome exactly. Even though we have data suggesting that people using food labels are less likely to develop metabolic syndrome, there would be some people who stopped reading food labels or started using food labels after being diagnosed with metabolic syndrome. If there are some people who started using food labels after being diagnosed with metabolic syndrome in the data, then the effects of using food labels on developing metabolic syndrome might be greater than we can infer from this research.

We concluded that the use of nutritional labeling has a significant association with metabolic syndrome with a 1.24 odds ratio and 1.14–1.35 95% CI. Although there are some groups with no consistent association between these two factors in the subgroup analysis, in the groups divided by smoking status, drinking status and stress status there was significant association between these two factors. If there are more detailed life trajectory data of using food labels and being diagnosed with metabolic syndrome, then it would be possible to find out more about the relationship between these two factors. Even though we had some limitations with our method, this research still supports the association between the use of food labels and metabolic syndrome. Especially, it shows the odds ratio in each feature of metabolic syndrome and they are all significant in the whole study population.

It also shows the odds ratio in each feature in the subgroup analysis. This can be helpful to figure out the way the use of food labels affects metabolic syndrome. This research emphasizes the importance of diet in preventing and treating metabolic syndrome.

5. Conclusions

We found out that people not using food labels tend to develop metabolic syndrome more than people using foods labels. Furthermore, people with a positive drinking status, smoking status or stress status were more vulnerable to metabolic syndromes when not using food labels. When discussing MetS, the type of nutrition should also be considered as a prime factor. So, we were working under the assumption that the group using nutritional labeling tend to show more concern for the type of nutrition on their diet. By that assumption we could just work on showing a relationship between use of nutritional labeling and MetS. Further studies are needed to show that there is a relationship
between using nutritional labeling and the type of nutrition which they take in. But we can still say that by using nutritional labeling we can decrease the probability of MetS. Therefore, we suggest that to prevent metabolic syndrome, education regarding using food labels are recommended, especially for people who drink, smoke or have stress.

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