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Association between nutrition labelling awareness and the metabolic syndrome: results from the Korean National Health and Nutrition Examination Survey (KNHANES) 2016–2018

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Abstract

Healthy dietary habits reduce the likelihood for the metabolic syndrome (MS). The present study investigated whether awareness of nutrition information is associated with a decreased likelihood for the MS after adjusting for potential confounders among Korean adults aged 20 years and older. Data were obtained from the Korean National Health and Nutrition Examination Survey 2016–2018. Of the 14 490 participants, 4001 (27·6 %) participants had the MS. In total, 3815 (26·3 %) participants checked nutritional facts and made labelling-dependent purchasing decisions (aware + consider), 7001 (48·3 %) checked nutritional facts but did not make labelling-dependent purchasing decisions or were aware of nutrition facts but did not check them when making food purchasing decisions (aware + not consider) and 3674 (25·4 %) were unaware of nutritional facts (not aware). The aware + consider group was less likely to develop the MS than other groups. The aware + not consider, and not aware groups were at higher association with the MS compared with the aware + consider group. Statistically significant associations were observed between the MS and several demographic characteristics including sex, age, household income, education level, employment status, public health insurance status, smoking status, alcohol consumption and aerobic exercise.

Key words: **Awareness of nutrition labelling: Metabolic syndrome: Young adults: Dietary habitation**

In recent years, growth of the commercial food industry in combination with increasing incomes has led to increased consumption of high-energy foods and increased daily energy intake, particularly in developing countries[1,2]. This shift in dietary habits has resulted in increased obesity and obesity-related diseases such as the metabolic syndrome (MS) and CVD[3]. According to data from the 2003–2018 National Health and Nutrition Examination Survey conducted in the USA, the reported prevalence of the MS increased from 31·2 % (95 % CI 31·2, 33·2 %) in 2003–2006 to 38·1 % (95 % CI 34·5, 41·9 %) in 2015–2018[4]. According to the Korean National Health and Nutrition Examination Survey (KNHANES) in 2014–2017, the prevalence of the MS among adults aged 20 years and older in Korea is 30·9 %[5]. The WHO estimates that the global prevalence of the MS is 300 million individuals in 2025[6].

The concept of the MS was introduced by Reaven in 1988[7]. Reaven described 'syndrome X' as insulin resistance clusters with glucose intolerance, dyslipidaemia and hypertension that was associated with increased association for CVD[8]. As the awareness and prevalence of these abnormalities increased, the condition was classified as the MS[9]. The MS is defined as a cluster of clinical cardiovascular risk factors including dyslipidaemia, impaired glucose tolerance, hypertension, physical inactivity and abdominal obesity[10,11]. The MS involves at least three risk factors related to waist circumference, blood pressure and serum concentrations of glucose, TAG and HDL-cholesterol under fasting conditions[12]. The pathogenesis of the MS is complex and incompletely understood; however, obesity, a sedentary lifestyle, and dietary and genetic factors contribute to the MS[13]. The presence of the MS increases the likelihood for complications in patients with type 2 diabetes mellitus, CVD and other chronic conditions[14,15].

The MS is associated with significant social and financial burden. The National Health Service in the UK has estimated the social cost of obesity to be £5·1 billion annually[16]. In addition, working-age individuals with the MS have significantly higher

Abbreviations: KNHANES, Korean National Health and Nutrition Examination Survey; MS, metabolic syndrome.

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medical costs compared to those without the MS ($626 in additional expenses per member per month)[17]. A primary objective in the management of the MS is to mitigate modifiable risk factors. Many previous studies have reported that lifestyle factors such as maintaining healthy body weight, exercise and healthy dietary intake may prevent the MS[18–24]. Furthermore, dietary interventions have been shown to improve diet quality, body weight and nutrition-related biomarkers. Healthy dietary habits reduce the likelihood for the MS, and several studies have shown that dietary counsellor programmes among individuals with the MS significantly decrease the MS components[23,24]. These findings highlight the importance of diet in metabolic health.

Despite this importance, many food choice decisions are dependent on momentary choice with limited consideration and information processing[25]. Given these points, healthcare policy authors have faced public health policy when the purpose is to improve consumer's healthier choice in order to reduce burden associated with nutrition-related chronic diseases[26]. As the consumption of processed foods has increased, the need for nutritional information has become an important public health issue[26]. In recent years, governments have promoted nutrition labels to increase public knowledge of nutritional information. Nutrition labelling defined any visual information on food ingredients on the package or container of food[27].

In South Korea, nutrition labelling of foods was mandated in 1995, to help consumers make informed choices about their food purchases[28]. Since then, consumers have been able to review and consider the nutrition value of food distributions[28,29]. Nutrition labelling also safeguards consumers from unreliable advertisement by providing exact nutrition information[30]. Nutrition labelling included information food size, energy, carbohydrate, protein, fat, sugar, *trans*-fatty acids, cholesterol and Na[31]. Previous study showed the effects of nutrition labelling use intake in lower energy, fat, cholesterol and sugar than non-user[31]. Nutrition labelling is intended to motivate consumers to choose more healthy food options and ultimately reduce association for the MS[29]. Therefore, label-dependent consumption would be more effective in health self-management among relatively vulnerable participants than the general population[31,32]. Despite increased MS prevalence and the expansion of nutrition labelling in South Korea, few studies have investigated their relationship. Numerous studies suggest a positive correlation between nutrition consumption and the MS; few have examined the effects of nutrition labelling and/or its risk factors. The introduction of nutrition labelling of foods in South Korea was expected to provide food-related health information to the South Korean population, the MS patients included, to help them better manage their health. The present study assessed the association between nutrition labelling awareness and the MS.

Experimental methods

Study population

The data were obtained from the KNHANES 2016–2018. The KNHANES are cross-sectional surveys that have been conducted annually since 1998 by the Korea Centers for Disease Control. The Korea Centers for Disease Control randomly selects households and invites them to complete the voluntarily survey. Stratified multistage probability sampling design was used with selection made from sampling units based on geographical area, sex and age groups from household registries.

A total of 24 269 participants completed the 2016–2018 KNHANES. To reduce the uncertainty associated with incomplete surveys, we excluded participants with incomplete data for the MS criteria including high blood pressure, elevated fasting blood glucose, hypertriacylglycerolaemia, low HDL-cholesterol and abdominal obesity. Participants who did not complete the nutrition awareness question were also excluded. The present study included individuals aged 20 years and older. After exclusions, 14 490 participants were included (Fig. 1).

Variables

The present study used the definition of the MS adopted by the National Cholesterol Education Program Adult Treatment Panel III and the Korean Journal of Obesity criteria[33,34]. Blood pressure was measured using a mercury sphygmomanometer in a seated position after 10 min of rest. Two measurements were made for all participants at 5-min intervals. An average of the two measurements was used in the analyses. Waist circumference was measured at the midpoint between the bottom of the rib cage and the top of the lateral border of the iliac crest on full expiration. Blood samples were collected from participants in the morning after overnight fasting and analysed at a centralised national laboratory. Participants with three or more of the following criteria were classified as having the MS: high blood pressure (≥130/85 mmHg or using medication to control blood pressure), elevated fasting blood glucose (≥5·55 mmol/l), hypertriacylglycerolaemia (≥8·325 mmol/l), low HDL-cholesterol (≤2·22 mmol/l in men and ≤2·775 mmol/l in women) and abdominal obesity (waist circumference of ≥90 cm for men and ≥85 cm for women).

The main independent variable was the use of nutrition labelling. We defined based on response for three phases question in KNHANES[30,32,35]. First, 'Do you know the nutrition labelling?'. Second, 'Do you read the nutrition label when buying or choosing processed foods?'. Third, 'Do you have the effect of your decision on buying food on nutrition labelling?'. These questions were answered with 'yes or no'. If participants responded as 'yes' for question, they responded for the next phase. The aware + consider group responded 'yes' three times in a row. The aware + not consider group answered as 'yes' for first question, then they answered as the next phase either 'yes' for second and 'no' for third question or 'no' for second question. The not aware group categorised who responded 'no' for first question. Awareness of nutrition information was divided into three categories: the aware + consider group checked nutrition facts and made labelling-dependent purchase decisions, the aware + not consider group checked nutrition facts but did not make labelling-dependent purchase decisions or were aware of nutrition facts but did not check them when making food purchase decisions and the not aware group was unaware of nutrition labelling[36] (Figs. 2 and 3).

Several demographic characteristics were collected. Participants were categorised by age (<40, 40–49, 50–59, ≥60 years), household

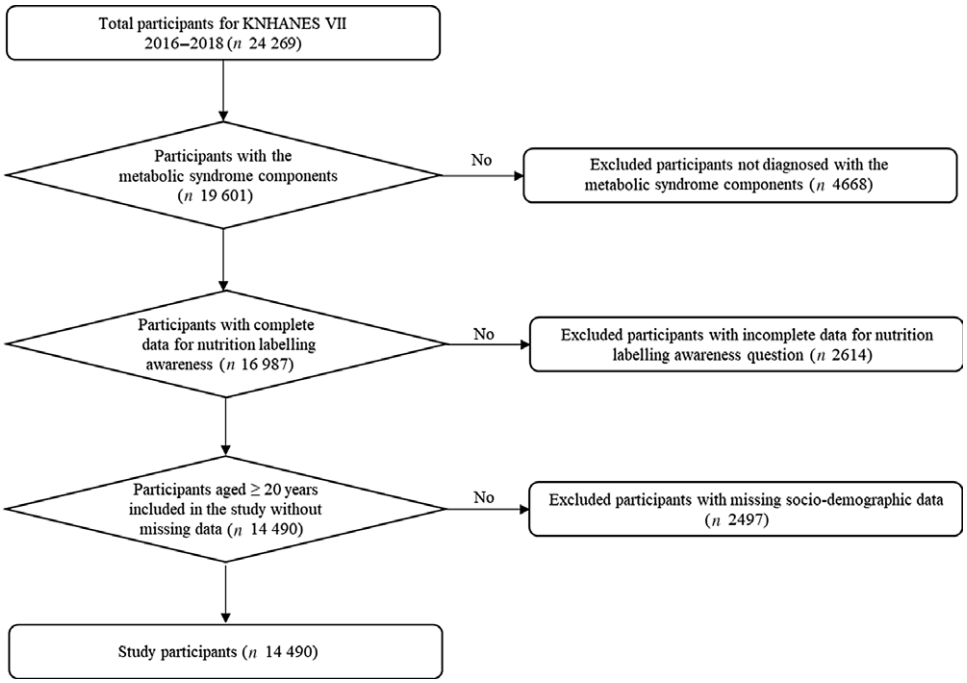

Fig. 1. Flow chart of study population. KNHANES, Korean National Health and Nutrition Examination Survey.

income quartile, educational level (elementary school graduation, junior high school, high school graduation, above university graduation), marital status (married, unmarried, divorced, widowed), employment status (unemployed, white-collar, blue-collar), public health insurance coverage (national health insurance, medical aid), supplemental private health insurance (yes, no) and smoking status (non-smoker, ex-smoker, current smoker). High-risk drinking (yes, no) was defined as the consumption of more than seven (male) or five (female) alcoholic drinks on a single occasion at least twice per week. The cut-off for weekly aerobic exercise (yes, no) was more than 2 h 30 min of moderate physical activity, 1 h 15 min of vigorous physical activity or a combination of both for >2 h 30 min, where 1 min of moderate physical activity was equal to 1 min of total physical activity time and 1 min of vigorous physical activity was equal to 2 min. Nutritional characteristics included energy intake (calculated as the average number of kJ consumed per d) and macronutrient intake (carbohydrate, protein, fat; calculated as the average number of g consumed per d).

Statistical analyses

All statistical analyses were performed using SAS version 9.4. Categorical variables were reported as frequencies and percentages, and descriptive statistics were generated using χ^2 tests. Continuous variables are reported as means and standard deviations, and study groups were compared using *t* tests. Logistic regression analyses were used to determine the OR and 95 % CI of the MS associated with nutrition labelling awareness while controlling for potential covariates including sex, age, household income, educational level, marital status, public health insurance coverage, supplemental private health insurance, smoking status, high-risk drinking, aerobic exercise, energy intake and macronutrient intake. Subgroup analyses were conducted using multivariable logistic regression analyses to investigate the association between the MS and sex, age, education level, household income, marital status and employment status. In the subgroup analyses, the Cochran–Armitage test was used to assess the association between the MS and each variable and the awareness of nutrition labelling. *P* values < 0·05 were considered statistically significant.

Results

General characteristics of the study population

A total of 14 490 participants were included, of which 4001 (27·6 %) had the MS and 10 489 (72·4 %) did not. The demographic and health characteristics of the study population are summarised in Table 1. In total, 3815 (26·3 %) participants were classified as aware + consider, 7001 (48·3 %) were classified as aware + not consider and 3674 (25·4 %) were not aware of nutrition labelling. Statistically significant differences were observed between nutrition labelling awareness and having the MS (aware + consider 18·2 % among participants with *v.* 81·8 % among those without the MS, aware + not consider 25·8 *v.* 74·2 %, not aware 40·8 *v.* 59·2 %; all $P < 0·0001$). In addition, there were differences in sex, age, household income, educational level, marital status, employment status, public health insurance, supplemental private health insurance, smoking status, high-risk drinking, aerobic exercise, energy intake and macronutrient intake between participants with and without the MS.

Univariable and multivariable logistic regression analyses of the relationship between awareness of nutrition labelling and the metabolic syndrome

Table 2 presents findings from univariate and multivariate logistic regression analyses of the relationships between nutrition

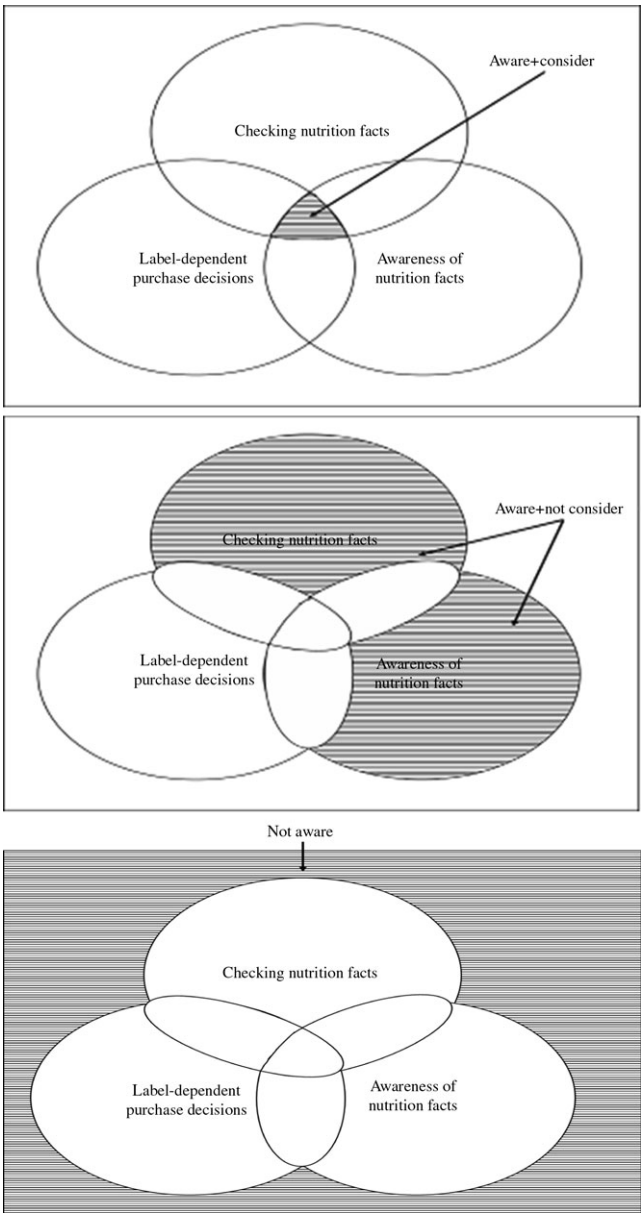

Fig. 2. Venn diagrams illustrating the concept of nutrition labelling awareness.

information awareness and the MS. In univariable logistic regression analyses, the aware + not consider (OR 1·56, 95 % CI 1·42, 1·72) and not aware (OR 3·10, 95 % CI 2·79, 3·44) groups had increased likelihood for the MS compared with the aware + consider group. In covariate analyses, male and older participants had increased likelihood for the MS compared with female and young participants. In addition, higher association for the MS was lower among participants with higher education levels compared to those with less education. Participants with high education level, other marital status (unmarried, divorced, widowed) or white-collar jobs were at reduced likelihood for the MS compared with those with low education level, married or unemployed. The MS was higher among participants on medical aid or not with private health insurance compared to those with national health insurance or with supplemental private health insurance. Smokers, high-risk drinkers and those that do not exercise regularly had a higher prevalence of the MS. In addition, energy, protein and fat intake were inversely correlated with the MS. In multivariable logistic regression analyses, participants in the not aware group had increased likelihood for the MS (OR 1·23, 95 % CI 1·08, 1·39); however, no statistically significant difference was observed in the aware + not consider group. Female, younger age and high education level were associated with lower MS. The MS was lower among participants with blue-collar jobs compared with those who were unemployed. Participants on medical aid had higher rates of the MS compared with those on the national health insurance plan. Participants with higher-risk health behaviours including smoking, high-risk drinking or no aerobic exercise were at increased likelihood for the MS.

Subgroup analyses of nutrition labelling awareness and the metabolic syndrome stratified by sex, age, household income, married status and employment status

The results of subgroup analyses on nutrition labelling awareness and the MS stratified by sex, age, household income, married status and employment status are summarised in Table 3. Among female participants, those in the aware + not consider and not aware groups had a statistically significant higher association for the MS compared with those in the aware + consider group. Among participants aged 60 years and older, those in the aware + not consider (OR 1·48, 95 % CI 1·19, 1·83) and not aware (OR 1·76, 95 % CI 1·43, 2·17) groups had a statistically significant higher likelihood for the MS compared with those in the aware + consider group. Among participants in the fourth quartile for household income, likelihood for the MS was significantly higher in the aware + not consider (OR 1·34, 95 % CI 1·09, 1·65) and not aware groups (OR 1·77, 95 % CI 1·37, 2·29). Only married participants in the aware + not consider (OR 1·19, 95 % CI 1·05, 1·34) and not aware (OR 1·51, 95 % CI 1·31, 1·75) groups had significantly higher association for the MS compared with the aware + consider group. Participants in the not aware group had increased likelihood for the MS compared with the aware + consider groups regardless of employment status (unemployed, OR 1·70, 95 % CI 1·40, 2·06; white-collar job, OR 1·28, 95 % CI 1·01, 1·63; blue-collar job, OR 1·32, 95 % CI 1·03, 1·69), with the trend being statistically significant ($P_{\text{for trend}} < 0·0001$).

Discussion

The present study identified an association between nutrition information awareness and the MS after adjusting for potential confounding among a nationally representative sample of adults aged 20 years and older in Korea.

Healthy behaviours are associated with a reduced incidence of the MS[37,38]. Previous studies have emphasised the importance of dietary behaviour in weight management and nutrition[39], with some suggesting that modifying dietary habits may be more effective than exercise in promoting metabolic health[29]. Current nutritional guidelines encourage the intake of healthy foods including fruits and vegetables and recommend reducing the consumption of energy-dense foods including

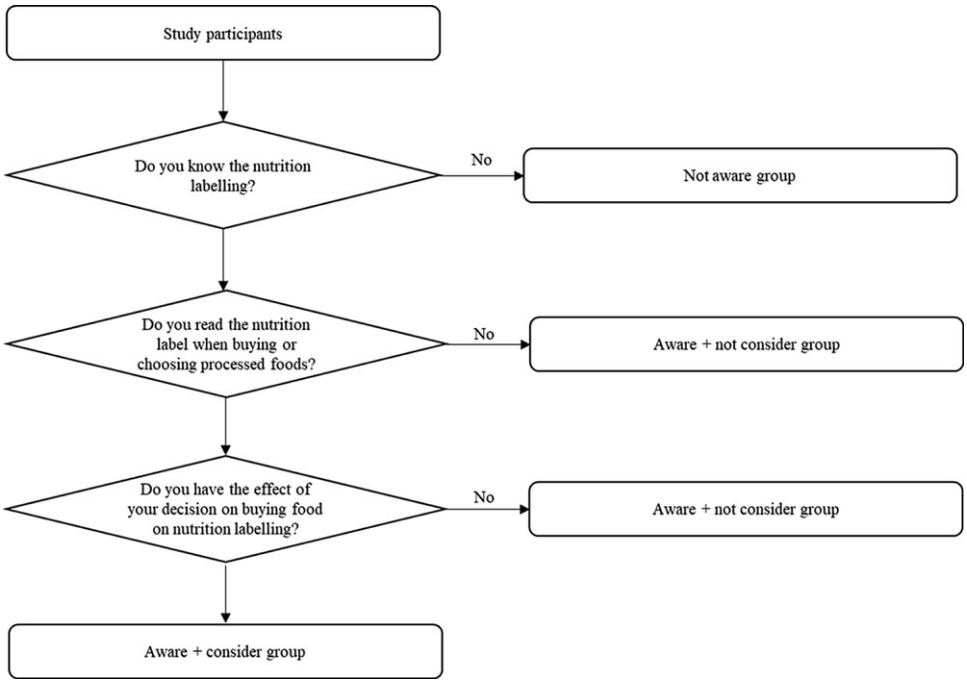

Fig. 3. Flow chart of nutrition labelling.

sugars, carbohydrates and processed foods[40]. The National Cholesterol Education Program Adult Treatment Panel III and the American Heart Association proposed dietary recommendations for preventing and treating the MS, which outlines the appropriate macronutrient distribution of carbohydrates, protein and fat and recommends limiting intake of *trans*-fat and refined sugar, and increasing consumption of fruits, vegetables and whole grains[41,42]. The WHO and Agriculture Organization of the United Nations have suggested that the increased consumption of energy-dense foods and fast foods has contributed to the increasing prevalence of obesity causing to the MS[43]. Energy-dense foods and fast foods have been associated with increased energy intakes and poor diet quality[44]. Unhealthy diets may contribute to insulin resistance by their higher levels of saturated fats[45]. Reducing imbalance diet might then become a viable therapeutic option not only for obesity but also for type 2 diabetes and the MS[46]. Energy-dense and fast foods have been associated with increased energy intakes and poor diet quality[44]. Unhealthy diet may contribute to insulin resistance by their higher levels of saturated fats, which have been shown to be related to impaired insulin sensitivity[45,46]. Reducing imbalance diet might then become a viable therapeutic option not only for obesity but also for type 2 diabetes and the MS[46].

Because of these problems, public healthcare experts seek primarily to improve nutrition quality worldwide. In South Korea, nutrition labelling provides information on nutritional content including energy, carbohydrate, protein, fat, sugar and cholesterol since 1995[47]. Research suggests that nutrition information on packaged food may influence food purchasing decisions and promote healthier dietary habits[48]. Previous studies have also looked into the association between the use of nutrition labels and the actual pattern of nutrient intake, some of which have shown that those who read nutrition labels tended to consume less energy and fats, and more fruits, vegetables[27]. We hypothesised that nutrition labelling-dependent purchasing decisions significantly affect the MS and explored likelihood between nutrition labelling and the MS.

The present study showed the MS was higher in participants who are not aware of nutrition labelling than who are taking nutrition labelling-dependent purchasing decisions. Consistent with the present study, nutrition labelling is positively associated with patient self-management of chronic diseases[32,36]. Our subgroup analysis showed positive relationship between nutrition labelling and socio-demographic characteristics. The present study showed the MS in males is higher than in females, with 32·4 % male with the MS and 24·2 % female with the MS. The previous study also confirmed that men have a higher relation factor level compared with women. Females were more likely than males to comply with dietary recommendations and choose foods than align with dietary guidelines[49]. In addition, females perceive nutrition as more important, use food labels more often and are more likely to be influenced by nutrition labelling in their food purchasing decisions compared with males[50]. In the present study, sex subgroup analyses showed analogous results with higher nutrition labelling awareness among females. The present study showed a promotion in the MS with advancing age, with significantly higher association of this condition among individuals when compared with younger groups[51]. In fact, age is known to increase the MS since several age-related physiological changes facilitate the development of insulin resistance[51,52]. In particular, postmenopausal women are vulnerable to metabolic changes due to oestrogen deficiency that increase total cholesterol and lipoprotein level[53]. Unhealthy diet contributes to increases of atherosclerosis and development of cardiovascular risk, especially at 50–69 years of age[46,53]. Ageing is accompanied by an increased need in

Table 1. General characteristics of the study population
(Numbers and percentages; mean values and standard deviations)

	Metabolic syndrome						
	Total		Yes		No		
Variable	*n*	%	*n*	%	*n*	%	*P*
Total	14 490	100·0	4001	27·6	10 489	72·4	
Awareness of nutrition labelling							<0·0001
Aware + consider	3815	26·3	695	18·2	3120	81·8	
Aware + not consider	7001	48·3	1806	25·8	5195	74·2	
Not aware	3674	25·4	1500	40·8	2174	59·2	
Sex							<0·0001
Male	6103	42·1	1975	32·4	4128	67·6	
Female	8387	57·9	2026	24·2	6361	75·8	
Age (years)							<0·0001
<40	3960	27·3	479	12·1	3481	87·9	
40–49	2712	18·7	623	23·0	2089	77·0	
50–59	2730	18·9	800	29·3	1930	70·7	
≥60	5088	35·1	2099	41·3	2989	58·7	
Household income							<0·0001
First quartile	3496	24·1	1068	30·6	2428	69·4	
Second quartile	3610	24·9	1035	28·7	2575	71·3	
Third quartile	3677	25·4	1003	27·3	2674	72·7	
Fourth quartile	3707	25·6	895	24·1	2812	75·9	
Education							<0·0001
≤Junior high school	4169	28·8	1740	41·7	2429	58·3	
High school	3858	26·6	1122	29·1	2736	70·9	
≥College	6463	44·6	1139	17·6	5324	82·4	
Marital status							
Married	10 283	71·0	2920	28·4	7363	71·6	0·001
Other (unmarried, divorced, widowed)	4207	29·0	1081	25·7	3126	74·3	
Employment status							<0·0001
Unemployed	5723	39·5	1753	30·6	3970	69·4	
White-collar	5417	37·4	1171	21·6	4246	78·4	
Blue-collar	3350	23·1	1077	32·2	2273	67·8	
Public health insurance							<0·0001
National Health Insurance	13 983	96·5	3775	27·0	10 208	73·0	
Medical Aid	507	3·5	226	44·6	281	55·4	
Supplemental private health insurance							<0·0001
Yes	11 306	78·0	2779	24·6	8527	75·4	
No	3184	22·0	1222	38·4	1962	61·6	
Smoking status							<0·0001
Non-smoker	8959	61·8	2175	24·3	6784	75·7	
Ex-smoker	3123	21·6	1003	32·1	2120	67·9	
Smoker	2408	16·6	823	34·2	1585	65·8	
High-risk drinking							<0·0001
No	12 908	89·1	3419	26·5	9489	73·5	
Yes	1582	10·9	582	36·8	1000	63·2	
Aerobic exercise							<0·0001
Yes	6251	43·1	1407	22·5	4844	77·5	
No	8239	56·9	2594	31·5	5645	68·5	
Average amount of total energy intake (kJ)							0·0161
Mean		8135·8		8015·3		8015·3	
SD		3719·2		3781·1		3694·5	
Average amount of daily carbohydrate intake (g)							0·6277
Mean		296·6		297·4		296·3	
SD		125·7		125·7		125·7	
Average amount of daily protein intake (g)							<0·0001
Mean		69·2		66·1		70·3	
SD		38·9		37·9		39·3	
Average amount of daily fat intake (g)							<0·0001
Mean		42·2		37·3		44·1	
SD		33·6		32·0		34·0	

Table 2. Univariable and multivariable logistic regression analyses of the relationship between nutrition labelling awareness and the metabolic syndrome (Odds ratios and 95 % confidence intervals)

	Metabolic syndrome			
	Univariable logistic regression		Multivariable logistic regression	
Variable	OR	95 % CI	OR	95 % CI
Awareness of nutrition labelling				
Aware + consider	1·00		1·00	
Aware + not consider	1·56	1·42, 1·72	1·08	0·97, 1·20
Not aware	3·10	2·79, 3·44	1·22	1·08, 1·39
Sex				
Male	1·00		1·00	
Female	0·67	0·62, 0·72	0·70	0·62, 0·79
Age (years)				
<40	1·00		1·00	
40–49	2·17	1·90, 2·47	2·06	1·79, 2·27
50–59	3·01	2·66, 3·42	2·57	2·22, 2·97
≥60	5·10	4·57, 5·69	3·69	3·17, 4·29
Household income				
First quartile	1·00		1·00	
Second quartile	0·91	0·83, 1·01	0·98	0·88, 1·09
Third quartile	0·85	0·77, 0·94	0·95	0·85, 1·06
Fourth quartile	0·72	0·65, 0·80	0·61	0·53, 0·69
Education				
≤Junior high school	1·00		1·00	
High school	0·57	0·52, 0·63	0·82	0·73, 0·92
≥College	0·29	0·27, 0·33	0·61	0·53, 0·69
Marital status				
Married	1·00		1·00	
Other (unmarried, divorced, widowed)	0·87	0·80, 0·95	1·02	0·93, 1·12
Employment status				
Unemployed	1·00		1·00	
White-collar	0·63	0·57, 0·68	1·01	0·91, 1·12
Blue-collar	1·07	0·98, 1·18	0·84	0·76, 0·94
Public health insurance				
National Health Insurance	1·00		1·00	
Medical Aid	2·18	1·82, 2·60	1·36	1·11, 1·66
Supplemental private health insurance				
Yes	1·00		1·00	
No	1·91	1·76, 2·08	1·03	0·93, 1·14
Smoking status				
Non-smoker	1·00		1·00	
Ex-smoker	1·48	1·35, 1·61	0·99	0·88, 1·13
Smoker	1·62	1·47, 1·79	1·32	1·16, 1·51
High-risk drinking				
No	1·00		1·00	
Yes	1·62	1·45, 1·80	1·65	1·44, 1·88
Aerobic exercise				
No	1·00		1·00	
Yes	0·63	0·59, 0·68	0·79	0·73, 0·86
Average amount of total energy intake (kJ)	0·99	0·99, 0·99	1·02	1·00, 1·03
Average amount of daily carbohydrate intake (g)	1·00	0·99, 1·00	0·99	0·98, 0·99
Average amount of daily protein intake (g)	0·97	0·96, 0·98	0·99	0·98, 1·02
Average amount of daily fat intake (g)	0·93	0·92, 0·95	0·97	0·95, 0·99

several nutrients, such as vitamins and minerals, whereas the overall energy requirements decline[54]. Therefore, nutrition labelling could be more crucial for elderly people due to hormone and metabolic changes[30]. However, regarding nutrition education experience, 94·8 % of older adults do not have an educational background in nutrition[55]. In addition, older adults have less awareness of the importance of the nutrients on food labels and therefore may be less likely to use nutrition labels in their food purchasing decisions[56]. For this reason, subgroup analysis showed that the aware + not consider and not aware groups have higher association MS than the aware + consider group in older adults. Therefore, more public health promotion of nutrition labelling should be provided for elderly populations[34,36]. The present study identified high-income level was a significant protective effect against the MS. Based on the previous study, high-income earner paid more attention towards healthy choices[57,58]. High-income households are more likely to consider the nutritional information, including energy, fat and cholesterol, on food labels than lower-income households[59,60]. Moreover, high-income earner has more healthy lifestyle than low-income earner such as leisure time physical activity and balance diet[57]. In the present study, education level influenced food label use among participants with the MS. Consumers with higher education may better understand the nutrition label information and the

Table 3. Subgroup analyses of nutrition labelling awareness and the metabolic syndrome by sex, age, household income, marital status and employment status
(Odds ratios and 95 % confidence intervals)

	Metabolic syndrome					
	Aware + consider	Aware + not consider		Not aware		
Variable	OR	OR	95 % CI	OR	95 % CI	$P_{for\ trend}$
Sex						
Male	1·00	0·94	0·80, 1·11	1·05	0·88, 1·27	<0·0001
Female	1·00	1·18	1·02, 1·36	1·71	1·45, 2·01	<0·0001
Age (years)						
<40	1·00	0·93	0·75, 1·16	0·95	0·62, 1·45	0·11
40–49	1·00	0·99	0·80, 1·22	1·48	1·05, 2·09	<0·0001
50–59	1·00	1·05	0·84, 1·29	1·35	1·03, 1·77	<0·0001
≥60	1·00	1·48	1·19, 1·83	1·76	1·43, 2·17	<0·0001
Household income						
First quartile	1·00	1·23	0·99, 1·51	1·24	0·98, 1·58	<0·0001
Second quartile	1·00	1·05	0·85, 1·29	1·41	1·11, 1·81	<0·0001
Third quartile	1·00	1·12	0·91, 1·38	1·62	1·27, 2·07	<0·0001
Fourth quartile	1·00	1·34	1·09, 1·65	1·77	1·37, 2·29	<0·0001
Marital status						
Married	1·00	1·19	1·05, 1·34	1·51	1·31, 1·75	<0·0001
Other (unmarried, divorced, widowed)	1·00	1·14	0·92, 1·41	1·24	0·97, 1·58	<0·0001
Employment status						
Unemployed	1·00	1·41	1·19, 1·68	1·7	1·40, 2·06	<0·0001
White-collar	1·00	0·91	0·77, 1·06	1·28	1·01, 1·63	<0·0001
Blue-collar	1·00	1·13	0·90, 1·44	1·32	1·03, 1·69	<0·0001

effects of nutrients on health, therefore informing their food purchasing decisions[59]. As a result, those with higher education may be more likely to adapt their dietary habits to promote metabolic health. These results should motivate healthcare professionals to consider the positive effects of that nutrition labelling-dependent purchasing decisions among specific population[32,36].

The present study had several limitations. First, the cross-sectional design of KNHANES precluded the ability to assess likelihood between nutrition labelling awareness and the MS. Second, the KNHANES are mostly self-reported surveys. Thus, questions on the socio-economic status, health behaviour, awareness of nutrition, and body size perception may be subject to recall bias. Third, the present study did not account for all health-related factors as part of the MS history. Despite these limitations, the study had several strengths. First, we identified several factors that contribute to the MS in relation to nutrition labelling. This provides an opportunity to develop and appropriate nutritional and educational interventions to manage the MS. Second, we used data from a nationally representative sample.

In conclusion, we found that nutrition labelling awareness is associated with the MS among a nationally representative sample of adults in Korea. Nutrition labelling-dependent purchasing decisions were associated positively with the MS. This finding could be used as evidence-based data for promoting the use of nutrition labelling to manage the MS in South Korea.

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By submitting a written statement and data utilisation plan, the KNHANES data are openly available at https://knhanes.cdc.go.kr/knhanes/index.do.

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H. H. C. and M. I. H. conceptualised the research. H. H. C. and D. W. L. conducted the formal analysis. H. H. C. and D. W. L. investigated the data. D. W. L. designed the methodology. M. I. H. managed project administration and supervision. H. H. C. wrote the paper. All authors reviewed and revised the manuscript and approved the manuscript for publication.

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