

## Educational attainment and differences in fruit and vegetable consumption among middle-aged adults in the Korean National Health and Nutrition Examination Survey IV

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### Abstract

We investigated whether socioeconomic differences affect fruit and vegetable (FV) consumption with respect to total intake and intake of various FV subgroups. Our study included 6667 adults aged 40-64 years who completed a dietary survey in the fourth Korean NHANES (2007-2009). FV intake was estimated from 24-hour recalls and food frequency questionnaires. Differences in FV consumption related to educational attainment were analyzed according to different nutritional categories of FV. Both men and women in the low-education group had the lowest intake of total FV and total fruits, and women also had the lowest intake of total vegetables. Also lowest in this group was consumption of mushrooms and vegetables (excluding kimchi) among men, and cruciferous and allium vegetables (excluding Chinese cabbage and radish) among women, while kimchi consumption was the highest in this group. Additionally, an association between educational level and intake of citrus fruits was evident among men. Adults in the low-education group consumed less carotene-rich FV, red fruit and/or vegetables, and dark-green leafy vegetables, fewer total vegetable dishes, and fewer types of fruit than in other groups. Men in this group had the lowest intake of yellow/orange fruit and/or vegetables, and women consumed the least folate-rich FV. There is a clear association between educational attainment and FV intake with regard to total intake, and to specific nutrients, bioactive compounds, colors, and variety.

**Key Words:** Fruit and vegetables (FV), educational level

### Introduction

Socioeconomic inequalities in health, including morbidity and mortality from cardiovascular disease (CVD) and cancer, are well documented [1]. They may be explained in part by differences in health-related behaviors, such as dietary choices [2]. Among dietary factors likely to contribute to health inequalities, fruit and vegetable (FV) consumption is of primary importance [3], due to the recognized protective effects of FV against chronic diseases [3], and the relationship between FV consumption and socioeconomic position (SEP) [2,4].

Studies investigating differences in FV intake according to SEP have focused on total intake of fruits and/or vegetables in terms of amounts and frequency [5-8]; however they have failed to improve our understanding of the relationship between FV consumption and health inequality. Because the specific food components found in various types of FV have different effects on chronic disease risks [9,10], and their association with SEP may vary, consumption of these components should be considered individually, in addition to total FV intake.

To study their nutritional composition, fruits and vegetables have been variously classified according to their botanical family,

color [11,12], antioxidant capacity [11,13], and dietary variety [14]. Many epidemiological studies to date have employed these classifications to investigate the relationship of FV with chronic diseases. Classification of FV by botanical family and color aids the study of vitamins, minerals, and bioactive compounds, e.g. carotene in yellow/orange FV, carotene and folacin in dark-green leafy vegetables, anthocyanins and lycopene in red FV, glucosinolates, isothiocyanates, and indoles in cruciferous vegetables, and allyl sulfides in allium vegetables [12]. Another classification focuses on antioxidant content, e.g. vitamin C [9,13,15], folate [13] and carotene [13,15], which are implicated in the etiology of diseases such as CVD and cancer, and may contribute substantially to health inequality [4]. Finally, particular attention can be paid to the dietary variety of FV, as only a varied diet can provide the broad range of nutrients needed to achieve protection against chronic diseases [12,16,17]. In fact, any of these health-related FV classifications could provide insight into the impact of specific types of FV on health inequality. Given the variety of protective effects, understanding the FV intake pattern in low-SEP adults could be important for health promotion. However, to our knowledge, few studies to date have investigated the relationship between FV intake and

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SEP in terms of these health-related effects.

Educational attainment is a strong socioeconomic indicator of differences in dietary intake [18], due to the close relationship between nutritional knowledge and health considerations on the one hand, and food choices on the other [19]. Therefore, the aim of our study was to investigate the association between the SEP, as indicated by educational level, and the intake of FV components that are relevant to health among Korean adults aged 40 to 64 years.

## Subjects and Methods

### Study population and data sets

The secondary data sets used in this study originated from the fourth Korean National Health and Nutrition Examination Survey (KHANES; 2007-2009). A total of 7100 participants aged 40-64 years completed the dietary survey. Subjects who did not provide information about their educational level ( $n=433$ ) were excluded, and the records of 6,667 individuals were used in our analysis. The study was approved by the Institutional Review Board of the Korea Centers for Disease Control and Prevention (KCDC), and written consent was obtained from all participants.

### Assessment of dietary intake

Dietary intake was estimated from 24-hour dietary recall and a food frequency questionnaire (FFQ). To reflect the Korean dietary preferences, potatoes and legumes were excluded from vegetable consumption, while mushrooms and seaweeds were included.

From the 24-hour dietary recalls we estimated the total amount of FV in the diet, and we categorized the FV intake by botanical family, specific nutrient content, color, and dietary variety. Total fruit included all raw, cooked, canned, frozen, or dried fruit and pure fruit juices, and total vegetable intake included all raw, cooked, canned, frozen or dried forms of most edible vegetables, seaweed, and mushrooms. Because kimchi (a fermented vegetable dish) is a major source of vegetables in the Korean diet, total intake was estimated with and without kimchi vegetables. Botanical families investigated in this study were mushrooms [20], seaweeds [21,22], allium vegetables [23,24], cruciferous vegetables [23,25], and citrus fruits [9,10,16,26]. Because of the high proportion of Chinese cabbage and radish in the Korean diet, cruciferous vegetables with/without Chinese cabbage and radish were also included.

The frequency of FV consumption was estimated from FFQs. Fruits included in the FFQs were tangerines, persimmons, pears, watermelons, oriental melons, strawberries, grapes, peaches, apples, bananas and oranges. Vegetables included tomatoes, Chinese cabbage, radishes, soy bean sprouts, spinach, cucumbers, carrots, peppers, squash, seaweeds and mushrooms. The total

frequency was calculated for each fruit and vegetable by summing their daily frequencies.

To classify FV as folate-, carotene-, and vitamin C-rich, a Korean food composition database [27] was used. Nutrient content (per 100 grams of each FV) was ranked for each nutrient, and FV in the highest tertile were considered nutrient-rich [13]. Thus, folate-rich vegetables were defined as raw, dried, and boiled vegetables including kimchi with folate content  $\geq 2,570$   $\mu\text{g}/100$  g, and folate-rich fruits were defined as raw, dried, and frozen fruits and fruit juices with folate  $\geq 34$   $\mu\text{g}/100$  g. By this definition, folate-rich vegetables included perilla leaves, carrot, mallow, red pepper, butterbur petiole, pepper leaves, *Ligusticum acutilobum* leaves, crown daisy, *Cudrama tricuspidata* leaves, mugwort, *Kalopanax pictus* leaves, Chinese chive, red paprika, parsley, spinach, *Angelica keiskei*, leaf beet (chard), rape, *Acanthopanax senticosus* buds, *Amaranthus mangostanus* (pig weed), other leafy vegetables (*Pimpinella brachycarpa*, *Ligularia fischeri*, *Patrinia scabiosefolia*, *Aster scaber*, *Ailantias altissima*, *Solidago vitga aurea*), kimchi vegetables (Yeolmukimchi, or young leafy radish and Yuchaekimchi, or young rape leaves), and all forms of seaweed, while folate-rich fruit included strawberry, mango, orange, raspberry, plum, kiwi, and banana.

Carotene-rich vegetables were defined as raw, dried, and boiled vegetables including kimchi with  $\beta$ -carotene content  $\geq 109$   $\mu\text{g}/100$  g, and carotene-rich fruits were defined as raw, dried, and frozen fruits and fruit juices with  $\beta$ -carotene  $\geq 90$   $\mu\text{g}/100$  g. Carotene-rich vegetables included rape, mustard, Brussels sprout, parsley, royal fern, broccoli, spinach, mugwort, crown daisy, asparagus, shepherd's purse, radish sprouts, bracken, cabbage, kale, welsh onion, water dropwort, lettuce, turnip leaves, chard, Chongkakkimchi (small radish kimchi), and all forms of seaweed, while carotene-rich fruits included persimmon, apricot, kumquat, watermelon, satsuma mandarin, mango, Japanese apricot, raspberry and orange.

Because dried, canned and frozen FV have lower vitamin C contents than their raw counterparts, only raw FV were included in the analysis. Thus, vitamin C-rich vegetables were defined as raw vegetables including kimchi with vitamin C content  $\geq 40$   $\text{mg}/100$  g, and vitamin C-rich fruits were defined as raw fruits and fruit juices with vitamin C content  $\geq 35$   $\text{mg}/100$  g. Vitamin C-rich vegetables included *Ligusticum acutilobum* leaves, castor plant leaves, sweet red pepper, *Cudrama tricuspidata* leaves, mustard, red pepper, rape, red paprika, cauliflower, broccoli, pepper leaves, kale, *Acanthopanax senticosus* buds, red mustard, Korean radish, shepherd's purse, green pepper, samchu, *Angelica keiskei*, spinach, Brussels sprout, lotus roots, young garlic stems, sebalramul, young pumpkin leaves, mallow, pak choi, chicory, celery, *Ligularia stenocophala*, perilla leaves, leek, royal fern, other leafy vegetables, and kimchi (Yuchaekimchi and Gatkimchi), while vitamin C-rich fruits included citron, longan, Chinese quince, strawberry, lemon, jujube, satsuma mandarin, kumquat, orange, *Actinidia arguta*, lychee, and grapefruit.

Next, we classified FV by the colors used in other epidemi-

ological studies of chronic diseases [9,10,12] as dark-green leafy vegetables, red fruit and/or vegetables and yellow-orange fruit and/or vegetables. Dark-green leafy vegetables included mustard, sweet potato leaves, chard, spinach, butterbur, mallow, *Angelica keiskei*, perilla leaves, chicory, young pumpkin leaves, soybean leaves, *Aster scaber*, *Pimpinella brachycarpa*, red mustard, *Cudrarna tricuspidata* leaves, *Ligularia fischeri*, and *Ligusticum acutilobum* leaves. Yellow/orange vegetables included carrots, yellow/orange paprika, and pumpkin. Red vegetables included tomatoes and tomato products, red pimento, red pepper, red beetroot, and red cabbage. Red fruits included cherry, strawberry, wild berry, watermelon, pomegranate and red apple. Yellow/orange fruits included orange, grapefruit, kumquat, lemon, mandarin orange, tangelo, apricot, persimmon, mango and yellow peach.

Dietary variety scores were calculated separately for fruit and for vegetables. The fruit variety score was the number of different types of fruit consumed, with each type given the score of 1 [14]. The vegetable variety score was calculated by adding the number of different side dishes that included vegetables as their main ingredient. The side dishes included were Saeng-chaе (raw vegetables with seasoning), Na-mul (blanched vegetables with seasoning), and kimchi.

#### Socioeconomic position (SEP)

Information about educational attainment is commonly used to determine SEP. Educational level, defined as the highest level of education completed, was divided into three groups: college or higher, high school, and middle school or lower.

#### Statistical analysis

Data analyses were performed with SAS 9.2 (SAS Institute Inc., Cary, NC, USA). Due to the complex sampling design of the KNHANES study, the relevant primary sampling units, stratification, and sample weights were taken into account in our analysis. General subject characteristics (%) were calculated using PROC SURVEYMEANS. FV intake by educational level and *P*-trends were calculated using regression analysis (PROC SURVEYREG). Values are presented as age-adjusted means, centered on the average age of all subjects. To perform the trend test, we considered the median values for each educational group as continuous variables.

## Results

Subject characteristics are shown in Table 1. Approximately 40% of both men and women were in the high-income group ( $\geq 250\%$  of the poverty threshold), 30% of men and 16% of women had college education, and 86% of men and 53% of women were employed. Most subjects were married and lived

in urban areas.

The total daily amounts and frequencies of FV consumption are shown in Table 2. Subjects in the low-education group had lower intakes of total FV, total vegetables excluding kimchi, and total fruit than subjects in other groups, but higher intakes of kimchi. In addition, the men had lower intakes of mushrooms, allium vegetables, and citrus fruit, and the women had lower intakes of allium vegetables, and cruciferous vegetables excluding Chinese cabbage and radish. There were clear differences in the frequencies of fruit and/or vegetable consumption across educational levels.

In terms of specific nutrients (Table 3), an association was found between educational level and the intake of carotene-rich FV in both genders, and folate-rich FV in women (*P*-trend < 0.005). Consumption of vitamin C-rich FV was not significantly associated with education in either men or women.

A positive association between educational level and FV intake was found in almost all color categories (Table 4): dark-green leafy vegetables, red vegetables and red fruit among men and women, and yellow/orange vegetables, yellow/orange fruit, and combined yellow/orange FV among men. However, this association was most evident with regard to red FV, and was seen in men and women.

FV consumption variety scores are shown in Table 5. Both men and women in the low-education group consumed fewer total vegetable dishes, Na-mul (blanched vegetables with

**Table 1.** Subject characteristics: Korean NHANES IV (2007-2009)

	Men (n = 2,726)	Women (n = 3,941)
	Sample (weighted %)	Sample (weighted %)
Age (Mean $\pm$ SE)	50.1 $\pm$ 0.15	50.3 $\pm$ 0.13
Income <sup>1)</sup> (%)		
$\geq 250\%$	1,126 (44.4)	1,471 (39.6)
120-249%	957 (36.0)	1,381 (37.0)
< 120%	589 (19.6)	1,012 (23.4)
Education (%)		
College and above	740 (30.3)	570 (15.9)
High school	945 (36.7)	1,341 (38.0)
Middle school and below	1,041 (33.0)	2,030 (46.1)
Occupation (%)		
Non-manual	640 (27.2)	390 (10.7)
Manual	1,657 (59.0)	1,754 (42.5)
Unemployed	415 (13.8)	1,779 (46.8)
Marriage (%)		
Living with spouse	2,456 (90.3)	3,276 (84.2)
Living w/o spouse	174 (6.3)	615 (14.9)
Unmarried	86 (3.4)	39 (0.9)
Residence (%) <sup>2)</sup>		
Metropolis	1,145 (45.4)	1,772 (48.6)
Urban	848 (34.6)	1,253 (33.9)
Rural	733 (19.9)	916 (17.5)

<sup>1)</sup> Based on the poverty threshold for each year

<sup>2)</sup> Metropolis refers to one of seven metropolises including Seoul; urban refers to Dong (neighborhood) municipal level, and rural refers to Eup (town) and Myeon (township) municipal levels

**Table 2.** Age-adjusted frequencies and mean daily consumption of total fruit and/or vegetables among middle-aged adults by educational level

	Education			P-trend <sup>2)</sup>
	College(+)	High school	Middle school(-)	
<b>Men</b>				
Daily intake (g/d)				
Total fruit	214.4 (15.2)	172.9 (10.9) <sup>1)</sup>	124.1 (9.2) <sup>***</sup>	< 0.0001
Citrus fruit	30.5 (5.1)	20.9 (3.1)	17.6 (3.3) <sup>*</sup>	0.0228
Total vegetables	427.6 (10.2)	419.1 (8.7)	414.1 (10.2)	0.3825
Total kimchi	153.6 (5.9)	168.9 (5.0) <sup>*</sup>	174.8 (5.8) <sup>*</sup>	0.0176
Vegetables excl. kimchi	274.1 (8.1)	250.2 (7.1) <sup>*</sup>	239.3 (8.0) <sup>**</sup>	0.0051
- Cruciferous vegetables	61.3 (3.8)	53.7 (3.0)	62.9 (3.9)	0.6126
- Cruciferous vegetables (excl. cabbage, radish)	12.4 (1.2)	7.4 (0.7) <sup>***</sup>	9.0 (1.7)	0.2046
- Mushrooms	5.1 (0.7)	4.0 (0.6)	3.0 (0.4) <sup>*</sup>	0.0105
- Seaweeds	6.3 (0.6)	5.6 (0.5)	7.1 (1.1)	0.4821
- Allium vegetables	59.4 (2.5)	62.5 (2.7)	52.8 (2.3)	0.0352
Total fruit and vegetables	642.0 (18.6)	592.1 (14.6) <sup>*</sup>	538.2 (14.1) <sup>***</sup>	< 0.0001
Frequency (times/d) <sup>3)</sup>				
Total fruit	1.24 (0.04)	1.10 (0.03) <sup>**</sup>	0.87 (0.03) <sup>***</sup>	< 0.0001
Total vegetables	5.71 (0.09)	5.73 (0.09)	5.34 (0.09) <sup>**</sup>	0.0044
Total fruit and vegetables	6.95 (0.11)	6.83 (0.10)	6.21 (0.11) <sup>***</sup>	< 0.0001
<b>Women</b>				
Daily intake (g/d)				
Total fruit	294.8 (18.3)	269.8 (13.9)	191.3 (8.1) <sup>***</sup>	< 0.0001
Citrus fruit	42.6 (10.7)	39.5 (4.5)	29.8 (3.6)	0.1554
Total vegetables	348.3 (9.8)	324.1 (6.7) <sup>*</sup>	310.2 (7.1) <sup>**</sup>	0.0073
Total kimchi	107.2 (5.8)	115.1 (3.8)	128.0 (4.4) <sup>**</sup>	0.0047
Vegetables excl. kimchi	241.1 (8.9)	209.0 (5.8) <sup>***</sup>	182.2 (5.1) <sup>***</sup>	< 0.0001
- Cruciferous vegetables	44.0 (3.2)	46.2 (2.6)	42.3 (1.9)	0.4068
- Cruciferous vegetables (excl. cabbage, radish)	8.7 (1.3)	7.3 (0.8)	5.3 (0.7) <sup>*</sup>	0.0154
- Mushrooms	5.8 (1.0)	4.0 (0.4)	3.8 (0.5)	0.1109
- Seaweeds	6.9 (1.0)	6.1 (0.7)	5.6 (0.5)	0.2830
- Allium vegetables	40.4 (2.1)	37.7 (1.5)	33.5 (1.3) <sup>**</sup>	0.0046
Total fruit and vegetables	643.1 (20.9)	593.9 (15.7) <sup>*</sup>	501.5 (11.0) <sup>***</sup>	< 0.0001
Frequency (times/d) <sup>3)</sup>				
Total fruit	2.01 (0.08)	1.66 (0.04) <sup>***</sup>	1.28 (0.04) <sup>***</sup>	< 0.0001
Total vegetables	5.89 (0.13)	5.71 (0.08)	5.27 (0.06) <sup>***</sup>	< 0.0001
Total fruit and vegetables	7.89 (0.18)	7.38 (0.10) <sup>**</sup>	6.55 (0.08) <sup>***</sup>	< 0.0001

Values are age-adjusted means (SE).

<sup>1)</sup> \*P-value < 0.05, \*\*P-value < 0.01, \*\*\*P-value < 0.001 compared to the high-education group

<sup>2)</sup> P-trend after age adjustment

<sup>3)</sup> Total frequency was calculated by adding daily frequencies for each item.

**Table 3.** Age-adjusted mean daily consumption of folate-, carotene-, and vitamin C-rich fruit and vegetables among middle-aged adults by educational level

Nutrient-rich FV (g)	Education			P-trend <sup>2)</sup>
	College (+)	High school	Middle school (-)	
<b>Men</b>				
Folate-rich FV <sup>3)</sup>	56.3 (3.6)	49.9 (3.1)	51.4 (3.6)	0.4161
Carotene-rich FV <sup>4)</sup>	144.7 (12.4)	107.4 (6.4) <sup>**1)</sup>	90.0 (6.2) <sup>***</sup>	< 0.0001
Vitamin C-rich FV <sup>5)</sup>	81.8 (5.9)	72.6 (4.2)	73.4 (5.2)	0.2946
<b>Women</b>				
Folate-rich FV <sup>3)</sup>	67.3 (8.5)	58.1 (3.6)	45.9 (2.4) <sup>*</sup>	0.0069
Carotene-rich FV <sup>4)</sup>	146.6 (14.2)	146.4 (9.6)	108.8 (5.7) <sup>*</sup>	0.0015
Vitamin C-rich FV <sup>5)</sup>	89.9 (13.3)	78.7 (5.6)	67.9 (4.0)	0.0790

Values are age-adjusted means (SE).

<sup>1)</sup> \*P-value < 0.05, \*\*P-value < 0.01, \*\*\*P-value < 0.001 compared to the high-education group

<sup>2)</sup> P-trend after age adjustment

<sup>3)</sup> Raw, dried, and boiled FV including kimchi, with folate content  $\geq 2570$   $\mu\text{g}/100$  g for vegetables and  $\geq 34$   $\mu\text{g}/100$  g for fruit

<sup>4)</sup> Raw, dried, and boiled FV including kimchi, with  $\beta$ -carotene content  $\geq 109$   $\mu\text{g}/100$  g for vegetables and  $\geq 90$   $\mu\text{g}/100$  g for fruit

<sup>5)</sup> Raw FV including kimchi, with vitamin C content  $\geq 40$  mg/100 g for vegetables and  $\geq 35$  mg/100 g for fruit

**Table 4.** Age-adjusted mean daily consumption of fruit and vegetables of different color among middle-aged adults by educational level

FV color categories (g)	Education			P-trend <sup>2)</sup>
	College (+)	High school	Middle school (-)	
<b>Men</b>				
Fruit				
Red fruit	67.8 (7.1)	48.5 (4.7) <sup>*1)</sup>	32.7 (4.3) <sup>***</sup>	< 0.0001
Yellow/orange fruit	62.2 (10.5)	45.5 (5.2)	35.2 (4.9) <sup>*</sup>	0.0129
Vegetables				
Dark-green leafy vegetables	19.5 (1.6)	17.7 (1.6)	14.1 (1.5) <sup>*</sup>	0.0141
Yellow/orange vegetables	8.3 (0.8)	4.7 (0.5) <sup>***</sup>	4.9 (0.6) <sup>***</sup>	0.0018
Red vegetables	26.5 (4.3)	14.4 (3.5) <sup>*</sup>	10.4 (3.7) <sup>**</sup>	0.0113
Combined FV				
Red FV	94.3 (8.1)	63.0 (6.1) <sup>***</sup>	43.1 (6.3) <sup>***</sup>	< 0.0001
Yellow/orange FV	70.5 (10.4)	50.3 (5.2)	40.1 (4.9) <sup>**</sup>	0.0053
<b>Women</b>				
Fruit				
Red fruit	96.5 (9.1)	83.0 (8.1)	51.2 (3.7) <sup>***</sup>	< 0.0001
Yellow/orange fruit	75.7 (13.3)	81.2 (7.2)	63.1 (5.3)	0.1573
Vegetables				
Dark-green leafy vegetables	17.5 (1.7)	13.3 (1.1) <sup>*</sup>	12.3 (1.1) <sup>*</sup>	0.0471
Yellow/orange vegetables	9.1 (2.0)	6.0 (0.8)	5.6 (0.7)	0.1227
Red vegetables	38.1 (6.1)	19.8 (3.0) <sup>**</sup>	10.5 (1.6) <sup>***</sup>	< 0.0001
Combined FV				
Red color FV	134.6 (11.0)	102.8 (8.8) <sup>*</sup>	61.7 (4.0) <sup>***</sup>	< 0.0001
Yellow/orange FV	84.8 (13.5)	87.3 (7.3)	68.6 (5.3)	0.1095

Values are age-adjusted means (SE).

<sup>1)</sup> \*P-value < 0.05, \*\*P-value < 0.01, \*\*\*P-value < 0.001 compared to the high- education group

<sup>2)</sup> P-trend after age adjustment

**Table 5.** Age-adjusted mean daily fruit and vegetable variety scores among middle-aged adults by educational level

Variety	Education			P-trend <sup>2)</sup>
	College(+)	High school	Middle school(-)	
<b>Men</b>				
Fruit variety <sup>3)</sup>	0.98 (0.05)	0.82 (0.04) <sup>**1)</sup>	0.57 (0.04) <sup>***</sup>	< 0.0001
Vegetable variety (total) <sup>4)</sup>	2.45 (0.06)	2.40 (0.05)	2.21 (0.05) <sup>**</sup>	0.0024
Na-mul (blanched vegetables with seasonings)	0.57 (0.03)	0.55 (0.03)	0.47 (0.03) <sup>*</sup>	0.0195
Sang-chaе (raw vegetables with seasonings)	0.38 (0.03)	0.35 (0.02)	0.29 (0.02) <sup>*</sup>	0.0088
Kimchi (vegetable dish)	1.50 (0.04)	1.50 (0.03)	1.45 (0.03)	0.3129
<b>Women</b>				
Fruit variety <sup>3)</sup>	1.48 (0.06)	1.21 (0.04) <sup>***</sup>	0.90 (0.03) <sup>***</sup>	< 0.0001
Vegetable variety (total) <sup>4)</sup>	2.42 (0.07)	2.37 (0.05)	2.24 (0.04) <sup>*</sup>	0.0228
Na-mul	0.68 (0.05)	0.61 (0.03)	0.52 (0.03) <sup>**</sup>	0.0029
Sang-chaе	0.38 (0.03)	0.37 (0.02)	0.32 (0.02)	0.0492
Kimchi	1.35 (0.04)	1.39 (0.02)	1.41 (0.03)	0.3171

Values are age-adjusted means (SE).

<sup>1)</sup> \*P-value < 0.05, \*\*P-value < 0.01, \*\*\*P-value < 0.001 compared to the high-education group

<sup>2)</sup> P-trend after age adjustment

<sup>3)</sup> Fruit variety score is the number of different types of fruit consumed in a day.

<sup>4)</sup> Vegetable variety score is the number of different vegetable dishes consumed in a day.

seasoning), and Saeng-chaе (raw vegetables with seasoning) than the high-education group. FV variety was strongly associated with educational attainment ( $P$ -trend < 0.0001).

## Discussion

Low FV consumption among adults with low educational status could lead to inadequate intake of antioxidant nutrients, considerably lowering their serum levels [28], which are strongly associated with chronic diseases [29]. Therefore, the differences

in quantity and quality of FV intake associated with educational attainment may be closely linked to health inequalities. Our results confirm the findings of previous studies [5,13,14] that demonstrate a relationship between educational attainment and total dietary intake of fruit and/or vegetables. Having expanded this investigation to include additional categories of FV, commonly used in epidemiologic studies, we have found that adults with low educational status are more likely to consume a poorer variety of FV, and less FV rich in certain antioxidants and of particular colors.

The low intake of carotene- and folate-rich FV in the low-education group corroborates the findings of a study in Australia that reported low intake of FV rich in vitamin C, folate, and vitamin A in low-income households [13]. The absence of a significant association between SEP and vitamin C in our study could be explained by the high consumption of kimchi, a dish rich in vitamin C, among adults with low education. Kimchi is the most popular side dish in Korea, and its major ingredients are cruciferous vegetables such as Chinese cabbage and radish. Kimchi contributed 84.0% of all cruciferous vegetables to the diets in our study; therefore it was reasonable to analyze their intake including and excluding kimchi. Interestingly, intake of cruciferous vegetables excluding Chinese cabbage and radish was low in the low-education group, especially among women. Although high consumption of cruciferous vegetables may have a protective effect against CVD [25], cerebrovascular disease [26] and cancers [16], it should be noted that kimchi is high in salt. This fact should not be overlooked when investigating the relationship between cardiovascular health and consumption of cruciferous vegetables in the Korean population. An association was also detected between low educational attainment and low intake of yellow/orange vegetables in men, and low intake of red fruit and/or vegetables in men and women. Red vegetables, such as tomatoes and its products, red pimento, red pepper, red beetroot, and red cabbage are rarely used in Korean cooking and are more expensive, which may explain why the differences in their consumption between the three groups were the most pronounced.

Any protective effects of FV are afforded by a combination of components [30]; therefore, a variety of FV should be consumed on a daily basis, especially by populations with low socioeconomic status [13]. In previous studies [8,14], the low SEP groups had lower variety scores for both fruit and vegetables. Despite some differences in methodology between these studies and our report, we have shown a clear association between educational level and variety scores for vegetable dishes in Korean men and women, and in particular for na-mul (blanched vegetables with seasoning) and saeng-chaе (raw vegetables with seasoning). There were no apparent differences in the variety of kimchi dishes between the three groups, probably because these are traditional and extremely popular dishes (at least one kimchi is served with most meals in Korea), with a long shelf life. The difference in variety between different SEP groups was

most apparent with regard to fruit consumption, which may be due to their limited affordability. Although greenhouse-grown fruits are available throughout the year in Korea, they are relatively expensive.

The high consumption of kimchi and the low intake and variety of FV in the low SEP adults may be explained by factors such as poor availability of FV (due to their high price) [19,31], lack of dietary knowledge [32,33], and individual food preferences [34]. High FV prices can be a barrier to purchasing FV among the low SEP adults who have limited food budgets [14,19,31]. Education may influence dietary knowledge [19,35] and the motivation to have a healthy diet [36]. A previous study showed that highly educated women chose to consume FV more frequently, and had a higher perceived ability to control their behavior [37]. Low nutritional knowledge can also affect food preferences and purchasing behavior [19], which in turn may be related to the individual's exposure to a variety of FV. Several studies have reported that food preferences may also be affected by other family members [34], and this was apparent in families of low socioeconomic status [38]. Therefore, family-based nutritional education could be a meaningful strategy to promote FV consumption among individuals with low SEP.

Our study has several limitations. FV intake was estimated from only one 24-hour recall, which may not reflect the subjects' normal intake. However, the FFQ was able to compensate for this weakness. Another limitation was the lack of data about the actual socioeconomic factors responsible for differences in FV consumption; therefore, the observed differences could not be fully explained. Despite this limitation, this is the first study to investigate socioeconomic differences as a factor affecting the quantity and quality of FV intake, focusing on FV color, variety and nutrient content. More importantly, the discovery of an association between socioeconomic status and consumption of FV with specific health-related properties may help us better understand nutrient and health inequalities. In addition, classification of FV by color and botanical family may be used to help consumers choose a wider variety of these foods on a daily basis.

In conclusion, low educational attainment is associated with lower total intake of FV, poorer dietary variety of FV, and lower intake of FV rich in specific antioxidant nutrients, belonging to specific botanical families, and of particular colors. Further study is needed to investigate the association between socioeconomic inequalities, chronic diseases and intake of FV with particular nutritional properties.

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