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ORIGINAL ARTICLE

# Trends in the inequality of fruit and vegetable consumption between education levels indicated by the Korea National Health and Nutrition Examination Surveys

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**BACKGROUND/OBJECTIVES:** The objective of this study was to investigate whether an inequality in fruit and/or vegetable (FV) consumption exists between adults of different educational levels in Korea and whether this has changed over the past decade.
**SUBJECTS/METHODS:** This study included adults (⩾20 years) who participated in the Korea National Health and Nutrition Examination Survey (1998–2009). The FV intakes were examined using 24-h dietary-recall surveys ($n = 35\,725$) and food frequency questionnaires ($n = 35\,400$). The relative index of inequality (RII) was used to examine the magnitude and trend of inequality in insufficient FV intake (<500 gram/day for total FV; <100 gram/day, less than once per day for fruits) between educational levels.
**RESULTS:** The low-education group had lower intakes of total FV, vegetables excluding Kimchi and fruit (both by frequency and quantity), but higher intakes of Kimchi, in both sexes in most years in which surveys were conducted. This group also had a higher proportion of adults with insufficient total FV and fruit intakes. The inequality, as indicated by the RII, was apparent in both sexes and in each survey year. The inequality in insufficient total FV intake increased between 1998 and 2009 in both sexes ($P < 0.05$). An increase in the inequality in fruit intake was only detected in women ($P < 0.0001$ for frequency and $P = 0.0285$ for quantity, from 2007 to 2009).
**CONCLUSION:** There is a wide discrepancy in total FV and fruit consumption across education levels among Korean adults. This inequality has increased over time for total FV intake in both sexes and for fruit intake in women.

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**Keywords:** fruit and vegetables (FV); relative index of inequality (RII); education level

## INTRODUCTION

It is well documented that fruit and/or vegetable (FV) consumption is correlated with morbidity and mortality due to chronic diseases,[1,2] and therefore is an important factor in public health. A possible relationship between FV consumption and increases in socioeconomic health inequalities in Korea has been suggested, as FV intake varies with socioeconomic position (SEP).[3,4] However, most studies on SEP and FV intake have only measured intake at a single time point.[5–9] Although some studies have examined trends in FV intake according to SEP, these were mostly performed in the West.[10–13]

Educational attainment, income and occupational social class are established indicators of SEP.[14] Of these indicators, education is the most likely to account for socioeconomic differences.[15–17] Education is closely correlated with knowledge and awareness, and thus may influence food choices through nutritional knowledge and health considerations.[18,19] Given the importance of food choices to public health, the relationship between education and food choices is a highly researched area, and a disparity in FV consumption between education levels has been suggested by many studies.[15,17]

The Republic of Korea has experienced enormous economic and social changes, and since the financial crisis in 1997, social inequality has deepened, as illustrated by an increase in the Gini coefficient (0.28 in 1996 to 0.34 in 2006) and the relative poverty rate (8.9% in 1996 to 17% in 2006).[20] This increased social inequality could contribute to a widened inequality in health behaviors including FV intake. Therefore, the objective of this study was to examine trends in the inequality of FV consumption between adults (aged ⩾20 years) with different levels of education by assessing the relative index of inequality (RII) in four cross-sectional nutritional surveys (the Korea National Health and Nutrition Examination Survey (KNHANES)) performed between 1998 and 2009.

## SUBJECTS AND METHODS

### Study population and data sets

Our analyses were based on the four KNHANES (1998, 2001, 2005 and 2007–2009), which were conducted by the Ministry of Health and Welfare and the Korea Centers for Disease Control and Prevention. The first three surveys were performed at a single time point, whereas the fourth was a continuous field survey with year-round data collection. The surveys were composed of four parts: (1) a household questionnaire to assess the structure of households and general characteristics of the members (sex, age, marital status and health insurance), (2) an individual questionnaire to assess sociodemographics (education, income, occupation, and region, and so on), general health status and health-related behaviors (medical history, smoking, drinking, and so on), (3) a 24-h dietary-recall survey and

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food frequency questionnaire (FFQ) and (4) an anthropometric and clinical examination. Data were collected from the stratified multistage probability samples of Korean households representing the civilian, non-institutionalized population. Additional details regarding study design and methods are provided elsewhere.[21]

The response rates were 89.5% in 1998, 88.0% in 2001, 89.9% in 2005, 71.2% in 2007, 77.8% in 2008 and 82.8% in 2009. A total of 36 819 dietary surveys were completed over the length of the project. Surveys ($n = 1094$) lacking corresponding education information were excluded from our study. Analyses were therefore performed using the data from 35 725 dietary surveys (7370 in 1998, 6970 in 2001, 6437 in 2005, 2588 in 2007, 5865 in 2008 and 6495 in 2009). A total of 15 443 surveys were completed by males and 20 282 by females. For FFQ, data were analyzed from 35 400 questionnaires (7355 in 1998, 6874 in 2001, 6428 in 2005, 2575 in 2007, 5787 in 2008 and 6381 in 2009).

Ethical approval for this study was obtained from the Institutional Review Board of the Korea Centers for Disease Control and Prevention and written consent was obtained from the participants. Further ethical approval for use of freely available KNHANES data is not required as it has been rendered anonymous.

### Dietary information

Dietary information was obtained from a 24-h dietary-recall survey and from a simple FFQ. A 24-h recall survey provides information on absolute intake of foods or nutrients, but this does not necessarily represent the usual diet. On the other hand, FFQs provide information on long-term dietary habits, but are relative. Therefore, in this study, we used data from both dietary-assessment methods to compromise for the limitations of each method.

The 24-h dietary-recall surveys were administered by trained dietary interviewers supervised by the Korea Health Industry Development Institute and were based on the food intake of one weekday. Supplementary tools, such as food models, two-dimensional example portion sizes and containers, were used to aid in recall. Fruit intake included all the raw, cooked, canned, frozen or dried fruits and vegetable intake included all the raw, cooked, canned, frozen or dried forms of most edible vegetables, seaweeds and mushrooms. A major source of vegetables in the Korean diet is Kimchi, which is a fermented vegetable dish made from pickled vegetables, garlic, onions, hot peppers, salt and other ingredients, and is typically served with every meal as a side dish. Kimchi is a good source of vitamin C and carotene, but is also high in sodium. Low-socioeconomic groups in Korea rely disproportionately on Kimchi for their vegetable intake.[22] Therefore, we calculated total vegetable intakes with and without Kimchi, as well as total Kimchi intake. Total consumption of FV was calculated from the 24-h recall data.

The food items investigated in FFQs were chosen based on the 24-h recall information from the previous survey; foods highly contributing to daily energy and nutrient intake, and foods eaten frequently or by a high proportion of subjects were selected.[23] Therefore, the number of food items varied between surveys: 58 (10 fruit and 19 vegetables) in 1998, 62 (10 fruit and 13 vegetables) in 2001, 63 (11 fruit and 14 vegetables) in 2005 and 2007–2009. Daily frequency of fruit consumption was calculated by summing the daily consumption frequency of raw, dried or canned forms of tangerines, persimmons, pears, watermelons, oriental melons, strawberries, grapes, peaches, apples, bananas, oranges and fruit juices. Daily frequency of vegetable consumption was calculated by summing the daily consumption frequency of raw, cooked, canned, frozen or dried forms of tomatoes, Chinese cabbage, radishes, soy bean sprouts, spinach, cucumbers, carrots, peppers, squash, seaweeds and mushrooms. The 1998 FFQ did not include mushrooms, bananas or grapes, however, as these are food items commonly consumed in recent years, they were included in our analyses for the later years.

Suggested daily FV intake and portion sizes vary between countries, and there is no universal recommendation for adequate intake of fruit, vegetables and total FV. In this study, we defined an adequate total intake of FV as a minimum of 500 g per day, as suggested in the Korean Health Plan 2010 guidelines.[24] For fruit intake, the Korean Nutrition Society recommends one serving per day for adults aged $\geqslant 65$ years and two or three servings for adults aged 19–64 years.[25] We defined an adequate fruit intake as 100 g per day (amount) and one serving per day (frequency).

### SEP indicators

Education, occupation and family income were measured as SEP indicators. Education was classified as the highest level of individual education completed and was categorized into three groups: middle school or less, high school and college or higher. Family income was defined as gross household income per month, and occupations were classified using the South Korean Standard Classification of Occupation. The use of family income may lead to the potential overestimation of income, as a substantial proportion of subjects were economically inactive (54.7% women and 23.7% men). Thus, given that education has been suggested to be the strongest indicator of SEP, we used education level as an indicator of SEP in this study.

### Statistical analysis

To take into account the complex sampling design and age differences, all the analyses (PROC SURVEYREG) included primary sampling units, stratification and sample weights and were centered on the average age of all the survey subjects. The age-adjusted proportions of the general characteristics were used to compare population differences between survey years. The age-adjusted least square means (with s.e.) were calculated for each education level for total FV intake, amount of fruit intake and frequency of fruit intake, along with the proportions of adults with inadequate intakes. The trend tests for linearity were conducted by treating the median value for each education group as a continuous variable in the analyses. All the analyses were conducted separately for men and women.

We used the RII to assess the magnitude of inequalities in inadequate FV consumption between education levels. The RII provides a meaningful measure of socioeconomic health inequalities over time.[26] The most frequently used method for presenting the RII is to use the exponent of the regression coefficient, which represents the odds or frequency predicted at the lowest point of the socioeconomic hierarchy divided by that predicted at the highest point.[27–29] To calculate the RII, a relative educational indicator needs to be calculated. The value of the relative indicator, ranging from 0 to 1, was calculated from the midpoint of the relative position in the cumulative population distribution for each educational hierarchy. It was entered as an independent variable into the log-binomial regression analyses[30] using PROC GENMOD,[31] and sample weights from the KNHANES were considered in the RII calculation. The trend for the RII was estimated by including an interaction term for the relative education indicator and a variable that identified the survey year.[30] As the RII increases, there exists a greater extent of inequality between educational hierarchies. Data analyses were performed with the software program SAS 9.2 (SAS Institute Inc., Cary, NC, USA).

## RESULTS

Table 1 shows the general characteristics of the subjects over time. Monthly household income and education level for both men and women showed an increasing trend. Approximately 50% of men and 30% of women had manual jobs throughout the surveys. Most subjects were married and the proportion of those living in a city or metropolitan area was approximately 80% throughout the surveys.

Mean daily FV consumption measured by amount (g/day) and frequency (times per day) is shown in Tables 2 and 3 for men and women, respectively. The low-education group had lower daily intakes of total FV, vegetables without Kimchi and fruit (in both amount and frequency) in most survey years, but higher Kimchi intakes than the high-education group. The discrepancy in fruit intake between education levels became more apparent throughout the years in both sexes.

The age-adjusted proportions of insufficient total FV and fruit consumption are shown in Table 4. The low-education group had a higher proportion of adults with insufficient consumption of total FV ($<500$ g/day) and fruit ($<100$ g/day or less than once per day) for both sexes and in almost all surveys. Although the proportions of adults with insufficient total FV intake were similar between sexes, the proportions of adults with insufficient fruit intake measured by both quantity and frequency were higher for males than for females.

The inequalities between educational levels in insufficient total FV and fruit intake, indicated by the RII, were apparent in both sexes and in each survey year (Figure 1), but in some cases

increased over time. A trend of increasing RII for the proportion of adults with inadequate total FV intake was observed for both sexes ($P<0.05$ for RII trend from 1998 to 2009). The RII values for proportions of adults with insufficient total FV intake (<500 g/day) were 1.20 (95% confidence interval (CI) 1.07, 1.36) in 1998 and 1.47 (95% CI 1.30, 1.67) in 2009 for men, and 1.27 (95% CI 1.13, 1.44) in 1998 and 1.52 (95% CI 1.36, 1.70) in 2009 for women. For the proportion of adults with an insufficient amount of fruit intake (<100 g/day), the inequality between education levels appears to increase over time in both sexes. However, only the increase for females from 2007 to 2009 is statistically significant ($P=0.0285$ for RII trend). Likewise, for the proportion of adults with an insufficient frequency of fruit intake (less than once per day), a significant increase in inequality between education levels was only observed for females; the RII gradually increased from 1.63 (95% CI 1.40, 1.91) in 1998 to 2.57 (95% CI 2.13, 3.10) in 2009 ($P=<0.0001$ for RII trend).

## DISCUSSION

The objective of this study was to investigate whether an inequality in FV consumption between education levels exists in Korea and whether it changed over a decade. An inequality in FV intake was observed for both daily mean intake and the proportion of adults with insufficient intakes in both sexes and in each survey year, and the inequality in total FV intake shows an increasing trend over time in both sexes. The increasing inequality trend was more apparent in the proportion of adults with insufficient fruit intake (<100 g/day or less than once per day) for females.

The positive relationship between FV and education level was consistent with previous studies.[6,19,32–35] For vegetables, Kimchi intake was higher in the low-education group, which is consistent with the results of a previous Korean study.[5] In contrast, vegetable intake without Kimchi was lower in the low-education group. This may reflect Korean cuisine, in which Kimchi is a traditional food with high availability and accessibility for all Koreans.[22] This finding may be relevant to the health inequalities in Korea, because Kimchi is well known to have positive health effects because of the presence of several beneficial nutrients,[36] but it is also high in salt, and the pickling process may lead to the loss of various bioactive components. Therefore, the role of Kimchi in health inequalities needs to be investigated further. Indeed, it would be useful to measure inequalities in consumption for other individual vegetables, as well as total vegetable consumption.

The inequality in fruit intake was greater than that of vegetable intake in this study. The diets of Koreans might be constrained by a scarcity of resources, with other living expenses such as visiting a physician possibly prioritized.[37] Within these constraints, some foods might be prioritized more than others; the priority of fruit may be lower than that of vegetables, especially in the low-education group. We also found a larger inequality in fruit intake in females than in males. Unfortunately, the reason for this gender disparity in fruit intake was not apparent and thus further study is needed to explain this.

Increasing trends in inequalities of proportions of adults with insufficient FV intake and fruit intake by amount and frequency were found. This has also been investigated in previous studies,[11–13,38] but unfortunately, direct comparison with those

**Table 1.** General characteristics of subjects according to the survey year

| | *Men* (n = *15 443*) | | | | | | *Women* (n = *20 282*) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *1998* | *2001* | *2005* | *2007* | *2008* | *2009* | *1998* | *2001* | *2005* | *2007* | *2008* | *2009* |
| Number | 3426 | 3194 | 2875 | 1023 | 2261 | 2664 | 3944 | 3776 | 3562 | 1565 | 3604 | 3831 |
| Age (years), mean (s.e.) | 42.2 (0.32) | 43.7 (0.31) | 42.7 (0.35) | 44.4 (0.59) | 44.0 (0.51) | 44.4 (0.43) | 43.5 (0.40) | 44.9 (0.37) | 44.6 (0.36) | 46.1 (0.57) | 46.0 (0.46) | 46.4 (0.43) |
| *Income (%)*[a] | | | | | | | | | | | | |
| ⩾250 | 20.4 | 36.0 | 41.0 | 36.9 | 41.0 | 40.8 | 20.9 | 33.8 | 38.9 | 35.4 | 35.8 | 38.9 |
| 120–250 | 42.7 | 42.6 | 38.3 | 36.5 | 34.3 | 36.3 | 41.0 | 43.1 | 38.6 | 37.6 | 37.2 | 35.9 |
| ⩽120 | 36.9 | 21.4 | 20.8 | 26.5 | 24.8 | 22.9 | 38.1 | 23.1 | 22.4 | 27.0 | 27.0 | 25.2 |
| *Education (%)* | | | | | | | | | | | | |
| College + | 28.1 | 36.2 | 39.7 | 32.2 | 32.8 | 32.8 | 18.1 | 23.3 | 28.2 | 24.8 | 26.0 | 27.4 |
| High school | 39.5 | 35.9 | 35.2 | 41.4 | 40.6 | 42.0 | 32.8 | 35.4 | 34.5 | 38.8 | 38.4 | 38.4 |
| Middle school | 32.4 | 27.9 | 25.1 | 26.5 | 26.6 | 25.2 | 49.1 | 41.3 | 37.3 | 36.4 | 35.6 | 34.2 |
| *Occupation*[b] *(%)* | | | | | | | | | | | | |
| Nonmanual | 21.2 | 24.4 | 23.2 | 24.6 | 25.0 | 28.4 | 10.7 | 11.8 | 15.6 | 15.4 | 14.8 | 18.6 |
| Manual | 56.4 | 52.1 | 51.9 | 49.2 | 51.5 | 48.0 | 33.6 | 30.6 | 32.5 | 25.2 | 30.3 | 30.2 |
| No Job | 22.5 | 23.6 | 24.9 | 26.2 | 23.5 | 23.7 | 55.7 | 57.5 | 51.9 | 59.5 | 54.8 | 51.3 |
| *Marital status*[c] *(%)* | | | | | | | | | | | | |
| Living with spouse | 81.1 | 78.5 | 71.7 | 74.8 | 73.2 | 73.0 | 69.9 | 70.6 | 64.6 | 71.2 | 68.7 | 68.1 |
| Living without spouse | 3.98 | 4.19 | 6.24 | 5.63 | 5.13 | 4.45 | 18.3 | 16.9 | 18.8 | 16.8 | 16.0 | 15.6 |
| Unmarried | 14.9 | 17.3 | 22.0 | 19.6 | 21.7 | 22.6 | 11.8 | 12.5 | 16.6 | 12.0 | 15.3 | 16.3 |
| *Region*[d] *(%)* | | | | | | | | | | | | |
| Metro city | 47.9 | 50.6 | 47.0 | 45.5 | 47.2 | 46.1 | 47.5 | 51.2 | 47.7 | 45.2 | 47.6 | 47.8 |
| City | 30.0 | 30.1 | 32.9 | 32.0 | 36.3 | 35.9 | 30.1 | 29.8 | 33.8 | 35.2 | 36.6 | 35.3 |
| Rural | 22.1 | 19.3 | 20.1 | 22.6 | 16.6 | 18.0 | 22.3 | 18.9 | 18.5 | 19.6 | 15.7 | 17.0 |

[a]Monthly household income expressed as a percentage of the poverty threshold by the Ministry of Health and Welfare. [b]Occupational class categories were as follows: nonmanual occupations (managers, professionals and clerks), manual occupations (service and sales workers, agricultural and fishery workers, craft and related trade workers, plant and machine operators and assemblers and elementary occupations) and no job (unemployed, retired, students and housewives). [c]Marital status is categorized as follows: living with spouse, living without spouse and unmarried. Living without spouse includes divorced, separated and widowed adults. [d]The metro city category includes seven metropolises, including Seoul.

**Table 2.** Age-standardized daily mean consumption of fruit and vegetables in the adult population according to the survey year and education level (men)

| *Food group, mean (s.e.)* | *1998* | | | | *2001* | | | | *2005* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *College +* | *High school* | *Middle school −* | P-*trend* | *College +* | *High school* | *Middle school −* | P-*trend* | *College +* | *High school* | *Middle school −* | P-*trend* |
| *Men* | | | | | | | | | | | | |
| *Daily intake (g/day)* | | | | | | | | | | | | |
| Total fruit and vegetables | 571 (17.4) | 569 (14.5) | 504 (13.1) | 0.0037 | 610 (14.5) | 601 (16.3) | 504 (16.6) | <0.0001 | 533 (12.9) | 497 (12.7) | 449 (16.5) | 0.0002 |
| Total vegetables[a] | 372 (11.3) | 387 (8.60) | 368 (8.68) | 0.7918 | 403 (9.01) | 422 (9.5) | 376 (10.3) | 0.0979 | 423 (9.39) | 433 (9.58) | 409 (13.1) | 0.5111 |
| Vegetables without kimchi | 227 (9.75) | 218 (5.91) | 189 (6.67) | 0.0032 | 238 (6.32) | 249 (7.49) | 204 (7.08) | 0.0016 | 273 (7.39) | 260 (7.02) | 241 (10.6) | 0.0201 |
| Total kimchi | 145 (5.49) | 168 (5.28) | 179 (5.97) | <0.0001 | 165 (5.85) | 173 (4.71) | 173 (7.70) | 0.3708 | 151 (4.67) | 173 (5.88) | 168 (6.19) | 0.0179 |
| Total fruit[b] | 199 (11.3) | 182 (10.9) | 136 (9.9) | <0.0001 | 207 (10.7) | 179 (11.4) | 127 (10.9) | <0.0001 | 110 (8.01) | 64.1 (6.91) | 39.7 (7.44) | <0.0001 |
| *Frequency (times per day)* | | | | | | | | | | | | |
| Total fruit and vegetables | 4.06 (0.12) | 3.61 (0.10) | 2.91 (0.14) | <0.0001 | 7.25 (0.11) | 7.29 (0.13) | 6.44 (0.14) | <0.0001 | 8.20 (0.15) | 7.82 (0.15) | 6.82 (0.20) | <0.0001 |
| Total vegetables[c] | 2.21 (0.07) | 1.96 (0.06) | 1.53 (0.06) | <0.0001 | 6.13 (0.09) | 6.27 (0.12) | 5.61 (0.13) | 0.0012 | 6.49 (0.11) | 6.36 (0.11) | 5.72 (0.16) | 0.0002 |
| Total fruit[d] | 1.85 (0.07) | 1.65 (0.06) | 1.38 (0.08) | <0.0001 | 1.12 (0.05) | 1.01 (0.05) | 0.83 (0.04) | <0.0001 | 1.71 (0.07) | 1.46 (0.06) | 1.10 (0.06) | <0.0001 |

| *Food group, mean (s.e.)* | *2007* | | | | *2008* | | | | *2009* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *College +* | *High school* | *Middle school −* | P-*trend* | *College +* | *High school* | *Middle school −* | P-*trend* | *College +* | *High school* | *Middle school −* | P-*trend* |
| *Daily intake (g/day)* | | | | | | | | | | | | |
| Total fruit and vegetables | 594 (28.0) | 543 (20.9) | 518 (35.8) | 0.0704 | 627 (20.8) | 532 (15.3) | 483 (21.0) | <0.0001 | 586 (15.6) | 561 (15.9) | 447 (16.9) | <0.0001 |
| Total vegetables[a] | 409 (21.0) | 364 (10.5) | 373 (22.1) | 0.1498 | 426 (12.5) | 382 (9.79) | 372 (13.8) | 0.004 | 400 (8.91) | 399 (9.38) | 356 (12.0) | 0.0108 |
| Vegetables without kimchi | 263 (18.9) | 220 (8.48) | 204 (12.8) | 0.0061 | 279 (10.8) | 232 (8.43) | 215 (11.9) | 0.0001 | 252 (6.04) | 237 (6.86) | 203 (8.72) | <0.0001 |
| Total kimchi | 146 (7.98) | 144 (7.69) | 169 (14.0) | 0.1841 | 147 (5.43) | 150 (5.09) | 158 (6.70) | 0.2170 | 148 (6.31) | 163 (5.26) | 153 (7.01) | 0.4641 |
| Total fruit[b] | 185 (17.9) | 179 (17.9) | 145 (25.1) | 0.2245 | 201 (16.3) | 150 (12.2) | 110 (15.1) | <0.0001 | 186 (11.6) | 161 (11.3) | 90.9 (11.3) | <0.0001 |
| *Frequency (times per day)* | | | | | | | | | | | | |
| Total fruit and vegetables | 7.00 (0.22) | 6.82 (0.19) | 6.50 (0.26) | 0.1797 | 6.85 (0.12) | 6.63 (0.11) | 5.94 (0.16) | <0.0001 | 6.63 (0.11) | 6.56 (0.13) | 5.73 (0.14) | <0.0001 |
| Total vegetables[c] | 5.60 (0.17) | 5.62 (0.15) | 5.49 (0.21) | 0.7473 | 5.65 (0.10) | 5.48 (0.09) | 5.08 (0.13) | 0.0007 | 5.45 (0.10) | 5.41 (0.10) | 4.87 (0.11) | 0.0001 |
| Total fruit[d] | 1.40 (0.09) | 1.19 (0.08) | 1.00 (0.09) | 0.0029 | 1.21 (0.05) | 1.15 (0.04) | 0.86 (0.05) | <0.0001 | 1.17 (0.04) | 1.15 (0.05) | 0.87 (0.05) | <0.0001 |

[a]Total vegetable intake (g) included all the raw, cooked, canned, frozen or dried forms of vegetables, mushrooms, seaweeds and also *Baechu kimchi*. [b]Fruit included all the raw, cooked, canned, frozen or dried fruits. [c]Vegetables included tomatoes, Chinese cabbage, radish, soy bean sprouts, spinach, cucumbers, carrots, peppers, squash, seaweeds and mushrooms. In 1998, mushrooms were not included. [d]Fruit included tangerines, persimmons, pears, watermelons, oriental melons, strawberries, grapes, peaches, apples, bananas, oranges and fruit juices. In 1998, bananas and grapes were not included.

**Table 3.** Age-standardized daily mean consumption of fruit and vegetables in the adult population according to the survey year and education level (women)

| *Food group, mean (s.e.)* | *1998* | | | | *2001* | | | | *2005* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *College +* | *High school* | *Middle school −* | P-*trend* | *College +* | *High school* | *Middle school −* | P-*trend* | *College +* | *High school* | *Middle school −* | P-*trend* |
| *Women* | | | | | | | | | | | | |
| *Daily intake (g/day)* | | | | | | | | | | | | |
| Total fruit and vegetables | 542 (20.8) | 563 (15.8) | 487 (14.2) | 0.0218 | 588 (20.7) | 615 (17.3) | 529 (14.4) | 0.0191 | 451 (13.5) | 448 (11.8) | 420 (11.0) | 0.1308 |
| Total vegetables[a] | 282 (9.74) | 304 (8.12) | 303 (8.45) | 0.2021 | 312 (8.3) | 332 (7.42) | 319 (8.1) | 0.7285 | 323 (7.79) | 342 (6.69) | 351 (8.74) | 0.0373 |
| Vegetables without kimchi | 174 (8.67) | 175 (6.24) | 164 (6.88) | 0.4164 | 195 (6.21) | 184 (6.08) | 173 (5.62) | 0.0169 | 218 (6.75) | 219 (5.65) | 220 (8.06) | 0.8668 |
| Total kimchi | 108 (5.28) | 129 (4.25) | 139 (4.49) | <0.0001 | 117 (4.85) | 148 (4.32) | 146 (4.92) | 0.0008 | 104 (4.36) | 123 (3.46) | 131 (4.26) | 0.00010 |
| Total fruit[b] | 260 (15.0) | 259 (12.5) | 184 (9.75) | <0.0001 | 276 (18.1) | 283 (14.8) | 210 (12.0) | 0.0059 | 128 (9.72) | 106 (8.97) | 68.3 (6.92) | <0.0001 |
| *Frequency (times per day)* | | | | | | | | | | | | |
| Total fruit and vegetables | 4.48 (0.20) | 4.08 (0.12) | 3.05 (0.12) | <0.0001 | 7.19 (0.18) | 7.31 (0.15) | 6.93 (0.12) | 0.2014 | 8.06 (0.20) | 8.36 (0.15) | 7.60 (0.17) | 0.1238 |
| Total vegetables[c] | 2.63 (0.11) | 2.35 (0.06) | 1.65 (0.06) | <0.0001 | 5.82 (0.15) | 6.06 (0.13) | 5.88 (0.12) | 0.9509 | 6.10 (0.15) | 6.41 (0.11) | 6.02 (0.13) | 0.7175 |
| Total fruit[d] | 1.85 (0.11) | 1.73 (0.08) | 1.39 (0.07) | 0.0011 | 1.37 (0.06) | 1.24 (0.05) | 1.05 (0.04) | <0.0001 | 1.95 (0.09) | 1.95 (0.08) | 1.57 (0.08) | 0.0027 |

| *Food group, mean (s.e.)* | *2007* | | | | *2008* | | | | *2009* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *College +* | *High school* | *Middle school −* | P-*trend* | *College +* | *High school* | *Middle school −* | P-*trend* | *College +* | *High school* | *Middle school −* | P-*trend* |
| *Daily intake (g/day)* | | | | | | | | | | | | |
| Total fruit and vegetables | 576 (38.4) | 501 (24.9) | 400 (22.9) | 0.0017 | 541 (16.9) | 526 (14.7) | 407 (13.0) | <0.0001 | 546 (15.7) | 517 (17.5) | 418 (18.3) | <0.0001 |
| Total vegetables[a] | 295 (11.9) | 281 (10.7) | 245 (11.0) | 0.0058 | 311 (9.2) | 302 (7.60) | 277 (8.42) | 0.0162 | 307 (8.83) | 291 (6.40) | 273 (11.2) | 0.0360 |
| Vegetables without kimchi | 195 (12.1) | 175 (9.46) | 140 (8.29) | 0.0010 | 209 (8.32) | 188 (6.43) | 168 (7.46) | 0.0017 | 213 (7.71) | 188 (5.51) | 154 (7.73) | <0.0001 |
| Total kimchi | 101 (6.08) | 107 (5.74) | 105 (7.07) | 0.6847 | 102 (4.79) | 115 (3.99) | 109 (5.08) | 0.4416 | 93 (4.51) | 103 (3.78) | 120 (7.11) | 0.0067 |
| Total fruit[b] | 281 (38.7) | 220 (21.3) | 155 (19.3) | 0.0165 | 230 (12.2) | 224 (13.1) | 130 (10.1) | <0.0001 | 240 (12.3) | 226 (15.2) | 145 (12.8) | <0.0001 |
| *Frequency (times per day)* | | | | | | | | | | | | |
| Total fruit and vegetables | 7.86 (0.37) | 7.47 (0.21) | 6.36 (0.23) | 0.0026 | 7.45 (0.16) | 7.20 (0.10) | 5.88 (0.11) | <0.0001 | 6.98 (0.13) | 6.88 (0.11) | 5.95 (0.14) | <0.0001 |
| Total vegetables[c] | 5.65 (0.23) | 5.57 (0.14) | 5.06 (0.16) | 0.0574 | 5.67 (0.12) | 5.60 (0.08) | 4.74 (0.09) | <0.0001 | 5.21 (0.10) | 5.35 (0.09) | 4.84 (0.12) | 0.0293 |
| Total fruit[d] | 2.21 (0.18) | 1.90 (0.10) | 1.30 (0.11) | 0.0002 | 1.79 (0.07) | 1.60 (0.05) | 1.14 (0.04) | <0.0001 | 1.77 (0.05) | 1.53 (0.04) | 1.12 (0.05) | <0.0001 |

[a]Total vegetable intake (g) included all the raw, cooked, canned, frozen or dried forms of vegetables, mushrooms, seaweeds and also *Baechu kimchi*. [b]Fruit included all the raw, cooked, canned, frozen or dried fruits. [c]Vegetables included tomatoes, Chinese cabbage, radish, soy bean sprouts, spinach, cucumbers, carrots, peppers, squash, seaweeds and mushrooms. In 1998, mushrooms were not included. [d]Fruit included tangerines, persimmons, pears, watermelons, oriental melons, strawberries, grapes, peaches, apples, bananas, oranges and fruit juices. In 1998, bananas and grapes were not included.

**Table 4.** Age-adjusted proportion (%) of insufficient fruit and vegetable intake according to the survey year and education level

| *Insufficient food intake* | *1998* | | | | *2001* | | | | *2005* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *College +* | *High school* | *Middle school −* | P-*trend* | *College +* | *High school* | *Middle school −* | P-*trend* | *College +* | *High school* | *Middle school −* | P-*trend* |
| *Men* | | | | | | | | | | | | |
| *Daily intake* | | | | | | | | | | | | |
| Insufficient fruit and vegetable intake (<500 g/day)[a] | 49.9 | 51.3 | 60.4 | 0.0006 | 46.7 | 48.2 | 59.1 | <0.0001 | 54.2 | 61.5 | 68.6 | <0.0001 |
| Insufficient fruit intake (<100 g/day)[b] | 49.5 | 58.0 | 66.5 | <0.0001 | 52.6 | 58.5 | 66.4 | <0.0001 | 67.8 | 81.7 | 88.8 | <0.0001 |
| *Frequency* | | | | | | | | | | | | |
| Insufficient fruit frequency ( less than once per day) | 37.7 | 44.1 | 55.4 | <0.0001 | 55.0 | 62.5 | 69.4 | <0.0001 | 43.9 | 51.6 | 60.0 | <0.0001 |
| *Women* | | | | | | | | | | | | |
| *Daily intake* | | | | | | | | | | | | |
| Insufficient fruit and vegetable intake (<500 g/day)[a] | 53.7 | 54.3 | 62.5 | 0.0145 | 51.1 | 47.8 | 54.7 | 0.2788 | 66.6 | 68.7 | 71.9 | 0.0977 |
| Insufficient fruit intake (<100 g/day)[b] | 42.2 | 40.5 | 51.4 | 0.0118 | 36.9 | 38.8 | 48.8 | 0.0005 | 63.6 | 70.1 | 79.7 | <0.0001 |
| *Frequency* | | | | | | | | | | | | |
| Insufficient fruit frequency ( less than once per d) | 39.9 | 42.2 | 55.7 | <0.0001 | 43.8 | 49.4 | 58.7 | <0.0001 | 35.4 | 36.7 | 48.6 | 0.0014 |
| *Insufficient food intake* | *2007* | | | | *2008* | | | | *2009* | | | |
| | *College +* | *High school* | *Middle school −* | P-*trend* | *College +* | *High school* | *Middle school −* | P-*trend* | *College +* | *High school* | *Middle school −* | P-*trend* |
| *Men* | | | | | | | | | | | | |
| *Daily intake* | | | | | | | | | | | | |
| Insufficient fruit and vegetable intake (<500 g/day)[a] | 49.9 | 53.9 | 61.0 | 0.0777 | 49.3 | 57.7 | 64.2 | <0.0001 | 49.5 | 53.8 | 67.8 | <0.0001 |
| Insufficient fruit intake (<100 g/day)[b] | 55.8 | 58.4 | 68.7 | 0.0400 | 60.4 | 64.3 | 75.5 | <0.0001 | 55.8 | 63.2 | 77.5 | <0.0001 |
| *Frequency* | | | | | | | | | | | | |
| Insufficient fruit frequency (less than once per day) | 47.9 | 52.0 | 64.1 | 0.0070 | 52.0 | 55.0 | 67.7 | <0.0001 | 51.3 | 57.7 | 69.0 | <0.0001 |
| *Women* | | | | | | | | | | | | |
| *Daily intake* | | | | | | | | | | | | |
| Insufficient fruit and vegetable intake (<500 g/day)[a] | 54.9 | 61.5 | 70.3 | 0.0051 | 56.2 | 61.0 | 69.6 | <0.0001 | 54.1 | 60.9 | 71.4 | <0.0001 |
| Insufficient fruit intake (<100 g/day)[b] | 47.2 | 52.8 | 53.5 | 0.3130 | 47.7 | 51.7 | 63.8 | <0.0001 | 41.1 | 50.4 | 62.4 | <0.0001 |
| *Frequency* | | | | | | | | | | | | |
| Insufficient fruit frequency (less than once per day) | 30.0 | 34.1 | 49.2 | 0.0006 | 31.9 | 33.4 | 52.2 | <0.0001 | 29.4 | 39.3 | 56.8 | <0.0001 |

[a]Fruit and vegetables included all kinds of fruits and vegetables and also *Baechu kimchi*. [b]Fruit included all the raw, cooked, canned, frozen or dried fruits.

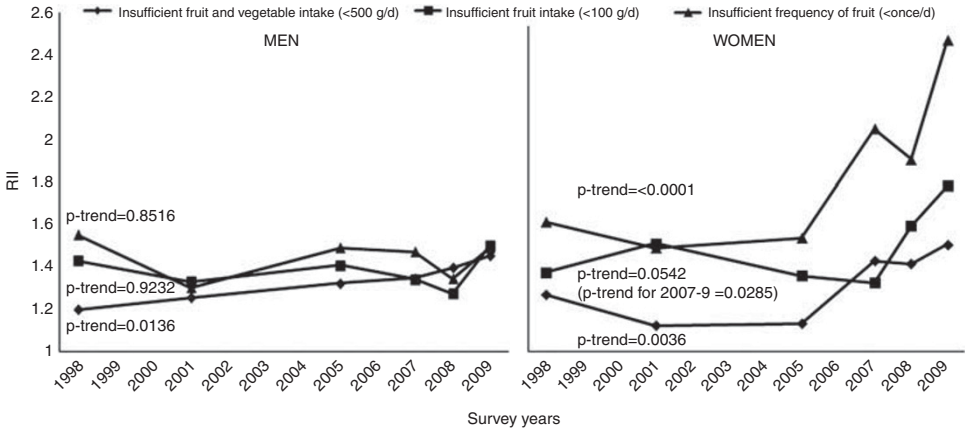


**Figure 1.** Trends of insufficient FV consumers by education level using RII according to the survey years.

studies is not possible, because the previous studies did not take into account changeable sample distributions across the education groups over time.

The inequality between education levels in total FV and fruit intake could be explained by several possibilities. The first is awareness of food information and nutritional knowledge.[18,19,32,39,40] There is a strong relationship between dietary knowledge and education level.[18,41] As nutritional knowledge can affect food preferences and purchasing behavior,[18] low nutritional knowledge and awareness in the low-socioeconomic groups may influence dietary inequality.[17,42] Another possible explanation is that education encourages individuals to hold beliefs and values about healthy foods, and these then motivate and regulate their food-related behaviors.[43] Women of higher educational attainment consume FV more frequently with more awareness and greater self-motivation.[44] An intervention study demonstrated that increased dietary self-motivation, perceived benefits and knowledge of recommended intakes can result in increased FV consumption 12 months later.[45] Therefore, future promotion efforts for FV consumption aimed at low-socioeconomic groups should include nutritional information and education related to the value of consuming FV. Incidentally, because our study also revealed a high proportion of adults with insufficient FV intake in the high-education group, FV intake should also be promoted to higher socioeconomic groups.

Some limitations of the present study need to be acknowledged. Firstly, the KNHANES data sets were not collected in the same season (1998 and 2001: autumn, 2005: spring and 2007–2009: throughout the year). This might influence the perceived trend in inequality, especially for the 1998–2005 surveys. Moreover, the 1998 survey did not include certain FVs, such as mushrooms, grapes and bananas. Therefore, caution should be exercised in the interpretation of the results, although additional analysis excluding these food items in all the surveys did not substantially change the perceived trend over time. In addition, only one 24-h dietary-recall survey was used to assess FV intake, and it reflects typical intake poorly.[46] However, the FFQ may compensate for the limitations of the single 24-h dietary recall, although it did not include every kind of FV due to the limited number of food items and did not estimate the absolute amount of FV consumed. Regardless of these limitations, it is noteworthy that there was an increasing inequality in FV intake and fruit with taking into account the changed distributions across the education levels over time using RII.

In conclusion, we found a wide discrepancy in total FV and fruit consumption between Korean adults with different education levels. The inequality in total FV intake has increased continuously from 1998 to 2009. The inequality in fruit intake was greater than that in vegetable intake, and the trend of increasing inequality was significantly greater in females.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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