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Perceptive and socio-economic predictors of varied fruit and vegetable intake

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Abstract

Daily consumption of a variety of fruits and vegetables (FVs) has been proven to be an essential requirement for keeping good health. Despite its importance, few studies have analyzed the determinants. This study characterizes FV-intake variety by considering both perceptive and socio-economic predictors within a single analytical framework. A questionnaire survey was conducted to measure FV-intake variety in terms of the number of FV items consumed in the last seven days and to collect perceptive and socio-economic information. Multivariate regression analysis demonstrates that critical thinking disposition, health locus of control, nutritional knowledge and variety seeking tendency are strong determinants for FV-intake variety, whereas a number of family members and age are the only significant variables among socio-economic factors. Overall, this paper finds that perceptive factors have stronger influences on FV-intake variety than socio-economic factors, suggesting a relative importance of improving general perceptions and education such as awareness or the way of thinking about health and nutrition.

Key Words: Fruits and vegetables; intake variety; perceptive factors; socio-economic factors

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Contents

1 Introduction

It is widely recognized that intake of fruits and vegetables (FVs) plays a protective role against major diseases. In fact, FV intake is found to decrease the risk of cardiovascular disease (CVD), and the risk of certain cancers, mainly in the digestive system, and it is inversely associated with body weight and fat mass (see, e.g., Davis et al., 2006, He et al., 2006, Vainio and Weiderpass, 2006, Guillaumie et al., 2010). Additionally, there is a growing consensus that intake of varied FVs is essential for keeping good health. For example, in the US, the governments dietary guidelines recommend eating a variety of FVs each day (U.S. Department of Health and Human Services, 2005, 2015). The American Heart Association has issued a similar recommendation as a way to reduce the risk of CVD (Lichtenstein et al., 2006). Given this state of affairs, this paper addresses the determinants for FV intake focusing on its variety.

Many previous works focus on quantity of FV intake rather than FV-intake variety and one major approach is to consider economic determinants (see, e.g., Behrman et al., 1988, Irala-Estevez et al., 2000, Grunert, 2005, Fuller et al., 2013, Conklin et al., 2013, Dave et al., 2016). Most of these works focus on the effect of various socio-economic status such as age (adults vs. children), gender, education, prices and income on quantity of various food intake. Conklin et al. (2013) show that old and children are very vulnerable and tend to have less FV intake in response to varied economic factors. Emanuel et al. (2012) focus on gender difference in the quantity of FV intake, demonstrating that females take more favorable perception and behaviors to FV intake than males. Behrman et al. (1988), Irala-Estevez et al. (2000), Wyse et al. (2012) and Dave et al. (2016) demonstrate that education and income generally increase the quantity of FV intake, leading to healthier food habits.

The other major approach is to address the quantity of FV intake by mainly considering not only economic but also perceptive (or cognitive) factors (Krebs-Smith et al., 1995, Cox et al., 1998, Guillaumie et al., 2010, Williams et al., 2010, Graham et al., 2013). Michie et al. (2005) demonstrate that a series of perceptive and cognitive factors including a variety of beliefs over consequences can characterize the behaviors related to health, claiming a further necessity of psy-

chological theory to promote healthy and diet practices. Following this work, many researches focus on perceptive factors analyzing the correlation with FV intake, concluding that perceptive and cognitive factors are important determinants for FV intake (see, e.g., Moser et al., 2005, Anderson et al., 2007, Watters et al., 2007, Wolf et al., 2008, Ball et al., 2009). Nollen et al. (2008) and Wyse et al. (2012) employ a randomized trial approach to see the causality between psychosocial factors and FV intake with intervention measures, finding that interventions to increase knowledge for the necessity of FVs can improve FV intake in treatment groups.

While FV intake has been empirically characterized in the past literature, there has been a long-standing debate on the relative importance between the quantity of FV intake and its varieties for improving health status (Padayatty and Levine, 2008, Bhupathiraju and Tucker, 2011, Griep et al., 2012, Cooper et al., 2012, Ye et al., 2013). Buchner et al. (2010) find that FV intake variety was negatively associated with lung cancer in current smokers. Bhupathiraju and Tucker (2011) demonstrate that variety, not quantity, of FV intake is inversely associated with coronary heart disease risk in Puerto Rican adults. Furthermore, they find that greater variety, not total quantity, of FV intake is associated with higher cognitive function in middle-aged and older Puerto Ricans. Cooper et al. (2012) show that FV variety is associated with a reduced risk of type 2 diabetes (T2D) even after controlling for FV quantity. Overall, FV variety, not the quantity, has been established to contribute to good health. Recent empirical evidence establish that FV variety is equally important to improve health status.

While numerous works have analyzed the determinants for FV intake focusing on perceptive and socio-economic factors, few works has been found to characterize the FV variety. To the best of our knowledge, no previous works exist to empirically examine the determinants of the FV intake variety, considering both socio-economic and perceptive factors. Therefore, we hypothesize that FV variety is associated with both fundamental perceptive factors and socio-economic ones, and seek to empirically characterize how these two kinds of factors contribute to the variety of FV intake within a single analytical framework. Our analysis demonstrates that perceptive factors of critical thinking disposition, health locus of control, nutritional knowledge and variety seeking

tendency are strong determinants for FV-intake variety, whereas a number of family members and age are the only significant variables among socio-economic factors. Overall, this paper finds that perceptive factors have stronger influences on FV-intake variety than socio-economic factors, suggesting a relative importance of improving general perceptions and education such as awareness and critical thinking about health and nutrition.

2 Methods

2.1 Sample

Data were collected via a Japanese Internet research company, Cross Marketing, Inc. As of September 2010, this company had 1,428,846 registered members throughout Japan. Among them, adult participants between 20 and 79 years old were invited via e-mail to participate in the preliminary survey. Then, some of the participants were invited to proceed to the main survey so that nine groups, defined by three age categories and three categories of geographical remoteness of residence, have the same sample size. Following Coveney and O'Dwyer (2009), distance to supermarkets is adopted as the measure of geographical remoteness. Specifically, in the preliminary survey, respondents were asked the distance between their residence and the nearest supermarket. The scales used for this question were $1 =$ within $0.8\,\mathrm{km}$ ($10\,\mathrm{min}$ by foot or $2\,\mathrm{min}$ by car); $2 =$ within $2.4\,\mathrm{km}$ ($30\,\mathrm{min}$ by foot or $6\,\mathrm{min}$ by car); $3 =$ more than $2.4\,\mathrm{km}$. Cross Marketing provided data on 600 respondents to the authors in such a way that the participants' identities remain unknown. All participants had agreed with this method of data utilization when they became registered members of Cross Marketing.

2.2 Measures

The socio-economic and demographic variables are included in the questionnaire: (1) age; (2) number of family members; (3) annual household income (scale: $1 =$ less than 3 million yen; $2 =$

3-4.99 milllion yen; 3 = more than 5 million yen; 4 = not willing to to answer); (4) education (scale: 1 = high school or less, 2 = junior college, 3 = university or graduate school); (5) car ownership (scale: 1 = yes and 2 = no). Also, perceptive variables included in the analysis are general scientific and nutritional knowledge and scales such as meal-making self-efficacy, health locus of control, variety-seeking tendency, and logical thinking disposition. The details of these instruments are given below.

Meal-making self-efficacy

The 10-item Meal-making Efficacy Scale was adopted. The items were as follows: (1) I can cut food materials in a way that is suitable for the meal that I am preparing, (2) I can arrange cooking in my own way, (3) I have techniques for making meals delicious, (4) I can arrange the process of cooking to enhance efficiency, (5) I can prepare delicious dishes at lower cost, (6) I can prepare meals that are good for my health, (7) I can prepare meals according to the health conditions of those who eat them, (8) I can consider menus taking nutritional balance into account, (9) I can decollate table of the meal to welcome guests, and (10) I can prepare meals taking into account the balance of the colors of the foods. Items were rated from 1 (strongly disagree) to 5 (strongly agree). The theoretical range of scores was 10-50.

Health locus of control

The internality subscale of the Japanese version of the Health Locus of Control Scale was adopted. The items were "If I get sick, my behavior determines how soon I get well," "I am in control of my health," "When I get sick, I am to blame," "If I take care of myself, I can avoid illness," and "If I take the right actions, I can stay healthy." Items were rated from 1 (strongly disagree) to 5 (strongly agree). The theoretical range was 5-25.

Dietary knowledge

Omori (2011) proposes a set of 12 questions to measure people's food and cooking knowledge in the Japanese context. Among them, two questions with high percentages (greater than 70 percent) of correct answers are deleted and 10 questions are adopted. Respondents are presented with 10 facts of cooking techniques regarding food materials; in each case, they are asked to give a response of 1 ("I know it"), 2 ("I have heard about it"), or 3 ("I do not know it"). The number of items for which respondents give an answer of 1 is defined as their nutrition knowledge score. The items are "It is impossible to make jellies using raw pineapples or kiwis," "Sugar and salt have infinite length of shelf life," "It is more difficult to peel boiled fresh eggs," "When stored with apples, fruits become ripe faster," "The meaning of the term Men-tori" (i.e., the technique of chamfering, or cutting off corners of food materials), "The meaning of the term Otoshi-buta" (i.e., the technique of resting the lid directly on food in the simmering liquid in the pot), "Agar and gelatin are different things," "In boiling green leafy vegetables, it is better not to use a lid on the pot," "The meaning of the term Nikogori" (i.e., the technique of making jellies with fish or meat broth rich in gelatin), and "The meaning of the term Sashi-mizu" (i.e., the technique of inserting a small amount of cold water into the pot to prevent it from boiling over).

Critical thiking disposition

The logical thinking subscale of the critical thinking disposition scale developed by Hirayama and Kasumi (2004) was adopted. This subscale consists of 13 items, which could be translated into English as follows: (1) "I am good at thinking about complex problems in an orderly fashion," (2) "I am good at collecting my thoughts," (3) "I am confident in thinking about things precisely," (4) "I am good at making persuasive arguments," (5) "I am confused when thinking about complex problems" (reversed item), (6) "I am usually the one to make decisions because my peers believe I can make fair judgments," (7) "I can concentrate on grappling with problems," (8) "I can continue working on a difficult problem that is not straightforward," (9) "I can think about things coherently," (10) "One of my shortcomings is that I am easily distracted" (reversed item), (11) "When

I think about a solution, I am unable to think about other alternatives" (reversed item), (12) "I can inquire into things carefully," and (13) "I am constructive in proposing alternatives." Items were rated from 1 (strongly disagree) to 5 (strongly agree). The theoretical range was 13-65.

Variety-seeking tendency

To measure variety-seeking tendency, VARSEEK scale developed by Van Trijp and Steenkamp (1992) is included in the questionnaire. This instrument includes eight items: (1) "When I eat out, I like to try the most unusual items, even if I am not sure that I would like them," (2) "While preparing food or snacks, I like to try new recipes," (3) "I think it is fun to try food items that I am not familiar with," (4) "I am eager to know what kind of food people from other countries eat," (5) "I like to eat exotic food," (6) "Items with which I am unfamiliar on a menu make me curious," (7) "I prefer to eat food products that I am accustomed to," and (8) "I am curious about food products that I am not familiar with (reversed item)." The items were rated on a five-point Likert scale ranging from 1 (completely disagree) to 5 (completely agree). The theoretical range was 8-40.

Scientific literacy

Items to measure scientific literacy were adopted from a questionnaire-based survey on attitudes toward science and technology conducted by National Institute of Science and Technology Policy (2001). The present study utilized 15 questions regarding general scientific knowledge. Questions 113 describe scientific propositions such as "the temperature of the core of the earth is extremely high," "all radioactive materials are artificial," and "the oxygen we breathe is produced by plants." The respondents are required to choose one of three alternatives: "The proposition is true," "the proposition is false," and "I have no idea." Question 14 asks whether light or sound is faster. Respondents are required to choose one of four alternatives: "light," "sound," "The speeds are nearly the same" and "I have no idea." Question 15 comprises two sub-questions, and respondents are considered to have answered the question correctly only when correct answers are chosen

for both of them. The first question asks if the sun is rotating around the earth or if the earth is rotating around the sun. Then, respondents who have answered the first sub-question correctly are asked how long it takes for the earth to make a trip around the sun. The scale is defined as the number of questions to which respondents provided correct answers. The theoretical range is 0-15.

Variety in fruit and vegetable intake

Access to varied FVs was determined by the number of FVs that a participant had eaten in the previous seven days. The respondents were presented with a list of 115 FVs generally available in Japanese supermarkets and grocery stores and were asked to mark all the items they had eaten in the past seven days. Fresh juices (orange, apple, other kinds of single fruit, and mixtures of multiple FVs) were also included in the list of 115 items.

3 Results

Multivariate regression analysis is applied to examine FV intake variety in terms of socio-economic and perceptive variables. The socio-economic variables included in the regression are (i) age, (ii) number of family members, (iii) annual household income, (iv) education, (v) car ownership, while the perceptive variables are (vi) general scientific and nutritional knowledge, and (vii) psychometric scales on healthy cooking efficacy, health locus of control, variety-seeking tendency, and critical thinking disposition. In addition, interaction terms were stepwise included. Scale scores to be included in the interaction terms were centered (i.e., normalized so that the mean of the variables was equal to zero).

3.1 Demographics and other characteristics of the sample

Table 1 summarizes the sample's characteristics. The average age of the 600 respondents is 51.6 ($SD = 16.4$ years). The most frequent annual household income level ($16.2\,\%$) is between 3 and 3.99 million yen (i.e., \$30 000 to \$39 900 USD). Of the respondents, 489 ($81.5\,\%$) own a

car, and the average VARSEEK score is 22.4 ($SD = 5.9$; theoretical range 540). The average meal-making self-efficacy scale score is 29.0 ($SD = 9.8$). Finally, regarding FV intake variety, as measured by the number of different FVs consumed in the last seven days, the average is 22.5 ($SD = 11.6$). Although the present study did not check the test-retest reliability of the 115 item FV variety scale, the Cronbachs alpha of this scale is quite satisfactory at 0.91, showing that the measurement is highly reliable. The Cronbachs alpha coefficients of the adopted six scales range between 0.77 and 0.96, demonstrating that the scales have acceptable levels of internal consistency.

[Table 1 about here.]

3.2 Regression analysis

Table 2 summarizes the results of regression analysis without interaction terms. Six predictors are significant at the $5\,\%$ level: (i) age ≥ 60 [$B = 6.06$ ($\beta = 0.25$) in reference to being in the 20-39 age group]; (ii) number of family members = "two" and "three" or more [$B = 5.33$ ($\beta = 0.21$) and $B = 4.09$ ($\beta = 0.18$), respectively, in reference to "one" (i.e., living alone)]; (iii) critical thinking disposition [$B = 0.19$ ($\beta = 0.14$)]; (iv) health locus of control [$B = 0.41$ ($\beta = 0.12$)]; (v) nutrition knowledge scale [$B = 0.73$ ($\beta = 0.17$)]; and (vi) variety-seeking scale [$B = 0.23$ ($\beta = 0.11$)]. In addition, the 20 variables shown in table 2 and a single interaction term are included in the regression model. We do this to check whether the interaction term significantly increases the log likelihood compared to the model. Six among the ${}_{20}C_2$ interaction terms listed in table 3 were found to significantly increase the log likelihood at the $5\,\%$ level, including "critical thinking disposition $\times$ nutrition knowledge" and "critical thinking disposition $\times$ female gender." We have finally run the regressions taking independent variables in table 2 together with the interaction terms that were identified to be significant in table 3 as a further robustness check. We find that the result does not change with the one shown in table 2 with respect to the magnitude and sign of statistically significant predictors. In other words, we confirm that our result in table 2 is quite robust against a change in model specifications. We include all the regression results of robustness check in the appendix.

200 [Table 2 about here.]

201 [Table 3 about here.]

Overall, our results seem to suggest that perceptive predictors play important roles in affecting FV intake, while only a few socio-economic variables are statistically significant. First, we discuss socio-economic variables in the regression results, focusing on those with statistical significances. When compared to the 39-and-under age group, older respondents (age 60 or older) had a greater variety of FV intake ($B = 5.89, p < 0.01$). This result is consistent with the finding of Anderson et al. (2007) that FV intake is positively associated with age. They suggest that older adults consume more FVs in part perhaps because they perceive greater social support (support from family for healthier eating) and are more likely to use self-regulation strategies. Some other studies, including those of Krebs-Smith et al. (1987), Resnicow et al. (2000) and Watters et al. (2007), include age as a candidate for predicting FV intake and did not observe a significant association. A possible explanation for this contradiction is that older people eat more varied FVs, but only small portions of them.

In reference to those living alone, those with two or more family members (including oneself) consume significantly more varied FVs ($B = 5.10$ and 3.90, respectively; $p < 0.01$). This result is consistent with the finding of Fuller et al. (2013) that household size is positively associated with FV consumption among people who use cars rather than public transportation for their major shopping trips. A similar result was reported by Temple (2006), who find, when studying a sample of Australian households headed by adults age 55 or over, that households with one family member have less dietary variety as measured by the total number of food items purchased within a two-week period. In summary, socio-economic predictors other than the aforementioned ones are not significant such as household income, distance to the supermarket and education (We may need to discuss why these variables are insignificant).

Regarding perceptive predictors, critical thinking disposition, heath locus of control, nutrition knowledge and variety seeking are identified to be statistically significant. The findings regarding the perceptive predictors offer a scientific basis on which to consider intervention measures to

promote people's varied FV intake. We discuss each of the variables step by step in what follows. First, critical thinking disposition is indeed significantly associated with variety in FV intake, with a standardized coefficient of 0.14 (table 2). Considering that Guillaumie et al. (2010) identify knowledge as a consistently significant predictor of FV intake in the research literature and that the standardized coefficient of nutrition knowledge is 0.17 in this study, it can be concluded that critical thinking disposition has a substantial effect on variety of FV intake, even though this is a general construct not intrinsically or logically connected with FV intake or health concerns. This finding suggests that people who have the motivation to tackle challenging situations actually do so in the context of FV intake. Critical thinking disposition is indeed positively and significantly associated with varied FV intake.

Health locus of control was found to interact with female gender and to significantly affect FV intake variety. This interaction could be interpreted in terms of the low rate of women's advancement in Japanese society, suggesting that women are more likely to be responsible for housekeeping activities, including buying food and cooking at home. It is of practical importance for family members responsible for these activities to hold the belief that their health is not predetermined and that they can control it. This finding could be useful outside Japan as well, if we interpret it as suggesting that being responsible for housekeeping interacts with health locus of control.

- A paragraph for nutrition knowledge scale
- A paragraph for variety seeking scale
- A paragraph to discuss how this research is novel in including both perceptive and socio-economic predictors to characterize FV-intake variety and emphasize "to the best of our knowledge, this is the first time that the role of critical thinking disposition and other perceptive factors in predicting FV intake variety has been demonstrated. "

4 Conclusion

This study examines the determinants of FV-intake variety by considering both perceptive and socio-economic predictors within a single analytical framework. A questionnaire survey was employed to gather the individual information of FV-intake variety in terms of the number of FV items consumed in the last seven days and to collect the associated perceptive and socio-economic factors. Our empirical analysis illustrates that general perceptive factors of critical thinking disposition, health locus of control, nutritional knowledge and variety seeking tendency are strong determinants for FV-intake variety, whereas a number of family members and age are the only significant variables among socio-economic factors. Overall, this paper suggests that general perceptive factors have stronger influences on FV-intake variety than socio-economic factors and implies a relative importance of improving general perceptions and education. More specifically enhancing awareness or the way of thinking about health and nutrition through education or some public health program can be a key for increasing FV intake variety.

Several limitations of our study should be mentioned. First, the present study aimed to explain only FV intake variety; future research should examine whether critical thinking disposition is associated with FV intake quantity as well. Second, the present study collected data via an internet research company. We should investigate whether the findings apply to a more general sample. Indeed, those who can access the Internet could be more likely to purchase food items via the internet, and such a special approach to obtaining foods may have influenced their FV intake. Given the results and limitations this research posed, future studies should conduct some field experiments and/or individual questionnaire surveys to examine how perceptions and education regarding health and nutrition can affect both FV intake variety and its quantity within a single framework. These caveats notwithstanding, it is our belief that this research can be considered an important first step to characterize FV intake variety in relation to perceptive and socio-economic factors. Our results clearly suggest relative importance of general perceptions and education regarding health and nutrition as compared to socio-economic factors.

5 Bibliography

Anderson, E. S., Winett, R. A., and Wojcik, J. R. (2007). Self-regulation, self-efficacy, outcome expectations and social supportt: Social cognitive theory and nutrition behavior. *Annals of behavioral medicine*, 34:304–312.

Ball, K., MacFarlane, A., Savige, D. C. C., Andrianopoulos, N., and Worsley, A. (2009). Can social cognitive theory constructs explain socio-economic variations in adolescent eating bbehaviour? A mediation analysis. *Health education research*, 24:496–506.

Behrman, J. R., Deolalikar, A. B., and Wolfe, B. L. (1988). Nutrients: Impacts and determinants. *World bank economic review*, 2:299–320.

Bhupathiraju, S. N. and Tucker, K. L. (2011). Greater variety in fruit and vegetable intake is associated with lower inflammation in Puerto Rican adults. *American journal of clinical nutrition*, 93:37–46.

Buchner, F. L., Bueno-de-Mesquita, H., Ross, M. M., Overvad, K., Dahm, C. C., Hansen, L., Tjnneland, A., Clavel-Chapelon, F., Boutron-Ruault, M. C., Touillaud, M., Kaaks, R., Rohrmann, S., Boeing, H., Nothlings, U., Trichopoulou, A., Zylis, D., Dilis, V., Palli, D., Sieri, S., Vineis, P., Tumino, R., Panico, S., Peeters, P. H., van Gils, C. H., Lund, E., Gram, I. T., Braaten, T., Sanchez, M. J., Agudo, A., Larranaga, N., Ardanaz, E., Navarro, C., Arguelles, M. V., Manjer, J., Wirfalt, E., Hallmans, G., Rasmuson, T., Key, T. J., Khaw, K. T., Wareham, N., N, N. S., Vergnaud, A. C., Xun, W. W., Kiemeney, L. A., and Riboli, E. (2010). Variety in fruit and vegetable consumption and the risk of lung cancer in the European perspective investigation into cancer and nutrition. *Cancer epidomiology, biomarkers and prevention*, 19:2278–2286.

Conklin, A. I., Maguire, E. R., and Monsivais, P. (2013). Economic determinants of diet in older adults: Systematic review. *Journal of epidemiology and community health*, 67:721–727.

Cooper, A. J., Sharp, S. J., Lentjes, M. A., Luben, R. N., Khaw, K., Wareham, N. J., and Forouhi, N. G. (2012). A prospective study of the association between quantity and variety of fruit and vegetable intake and incident type 2 diabetes. *Diabetes care*, 35:1293–1300.

Coveney, J. and O'Dwyer, L. A. (2009). Effects of mability and location on food access. *Health place*, 15:45–55.

Cox, D. N., Anderson, A. S., Lean, M. E., and Mela, D. J. (1998). UK consumer attitudes, beliefs and barriers to increasing fruit and vegetable consumption. *Public health nutrition*, 1:61–68.

Dave, D., Doytch, N., and Kelly, I. R. (2016). Nutrient intake: A cross-sectional analysis of trends and economic correlates. *Social science and medicine*, 158:158–167.

Davis, J. N., Hodges, V. A., and Gillham, M. B. (2006). Normal-weight adults consume more fiber and fruit than their age- and height-matched overweight/obese counterparts. *Journal of the American dietetic association*, 106:833–840.

Emanuel, A. S., McCully, S. N., Gallagher, K. M., and Updegraff, J. A. (2012). Theory of planned behavior explains gender difference in fruit and vegetable consumption. *Appetite*, 59:693–697.

Fuller, D., Cummins, S., and Matthews, S. A. (2013). Does transportation mode modify associations between distance to food store, fruit and vegetable consumption and BMI in low income neighborhoods? *American journal of clinical nutrition*, 97:167–172.

Graham, D. J., Pelletier, J. E., Neumark-Sztainer, D., Lust, K., and Laska, M. N. (2013). Perceived social-ecological factors associated with fruit and vegetable purchasing, preparation, and consumption among young adults. *Journal of the academy of nutrition and dietetics*, 113:1366–1374.

Griep, L. M. O., Verschuren, W., Kromhout, D., Ocke, M. C., and Geleijnse, J. M. (2012). Variety in fruit and vegetable consumption and 10-year incidence of CHD and stroke. *Public health nutrition*, 15:2280–2286.

Grunert, K. G. (2005). Food quality and safety: consumer perception and demand. *European review of agricultural economics*, 32:369–391.

Guillaumie, L., Godin, G., and Vezina-Im, L. (2010). Psychological determinants of fruit and vegetable intake in adult population: A systematic review. *International journal of behavioral nutrition and physical activity*, 7:1–12.

He, F. J., Nowson, C. A., and MacGregor, G. A. (2006). Fruit and vegetable consumption and stroke: Meta analysis of cohort studies. *Lancet*, 367:320–326.

Hirayama, R. and Kasumi, T. (2004). Effects of critical thinking on interpretation of controversial issues: Evaluating evidences and drawing conclusions. *Japanese journal of educational psychology*, 52:186–198. (in Japanese).

Irala-Estevez, J. D., Groth, M., Johansson, L., Oltersdorf, U., Prattala, R., and Martinez-Gonzalez, M. A. (2000). A systematic review of socio-economic differences in food habits in Europe: Consumption of fruit and vegetables. *European journal of clinical nutrition*, 54:706–714.

Krebs-Smith, S. M., Heimendinger, J., Patterson, B. H., Subar, A. F., Kessler, R., and Pivonka, E. (1995). Psychosocial factors associated with fruit and vegetable consumption. *American journal of health promotion*, 10:98–104.

Krebs-Smith, S. M., Smiciklas-Wright, H., Guthrie, H. A., and Krebs-Smith, J. (1987). The effects of variety in food choices on dietary quality. *Journal of the American dietetic association*, 87:897–903.

Lichtenstein, A. H., Appel, L. J., Brands, M., Carnethon, M., Daniels, S., Franch, H. A., Franklin, B., Kris-Etherton, P., Harris, W. S., Howard, B., Karanja, N., Lefevre, M., Rudel, L., Sacks, F., Horn, L. V., Winston, M., and Wylie-Rosett, J. (2006). Diet and lifestyle recommendation revision 2006: A scientific statement from the American heart association nutrition committee. Technical report, American heart association.

Michie, S., Johnston, M., Abraham, C., Lawton, R., Parker, D., and Walker, A. (2005). Making psychological theory useful for implementing evidence based practice: a consensus approach. *Quality and safety in health care*, 14:586–606.

Moser, R. P., Green, V., Weber, D., and Doyle, C. (2005). Psychosocial correlates of fruit and vegetable consumption among African American men. *Journal of nutrition education and behavior*, 37:306–314.

National Institute of Science and Technology Policy (2001). Survey on attitudes toward science and technology. NISTEP report no. 72 (in Japanese).

Nollen, N., Befort, C., Pulvers, K., James, A. S., Kaur, H., Mayo, M. S., Hou, Q., and Ahluwalia, J. S. (2008). Demographic and psychosocial factors associated with iincreased fruit and vegetable consumption among smokers in public housing enrolled in a randomized trial. *Health psychology*, 27:252–259.

Omori, R. (2011). The dietary knowledge and awareness of university students. *Bulletin of Faculty of education, Utsunomiya university*, 61:119–125. (in Japanese).

Padayatty, S. J. and Levine, M. (2008). Fruit and vegetables: Think variety, go ahead, eat! *American journal of clinical nutrition*, 87:5–7.

Resnicow, K., Wallace, D., Jackson, A., Digirolamo, A., Odom, E., Wang, T., Dudley, W. N., Davis, M., Mitchell, D., and Baranowski, T. (2000). Dietary change through African American churches: Baseline results and program description of the eat for life trial. *Journal of cancer education*, 15:156–163.

Temple, J. B. (2006). Household factors associated with older Australian's purchasing a varied diet: Results from household expenditure data. *Nutrition and dietetics*, 63:28–35.

U.S. Department of Health and Human Services (2005). Dietary guidelines for Americans 2005. Technical report, U.S. Department of Agriculture.

U.S. Department of Health and Human Services (2015). Dietary guidelines for Americans 2015-2020. Technical report, U.S. Department of Agriculture.

Vainio, H. and Weiderpass, E. (2006). Fruit and vegetables in cancer prevention. *Nutrition and cancer*, 54:111–142.

Van Trijp, H. and Steenkamp, J. (1992). Consumers' variety seeking tendency with respect to ffood: Measurement and managerial implications. *European review of agricultural economics*, 16:181–195.

Watters, J. L., Saita, J. A., and Galanko, J. A. (2007). Associations of psychosocial factors with fruit and vegetable intake among African-Americans. *Public health nutrition*, 10:701–711.

Williams, L., Ball, K., and Crawford, D. (2010). Why do some socioeconomically disadvantaged women eat better than others? an investigation of the personal, social and environmental correlates of fruit and vegetable consumption. *Appetite*, 55:441–446.

Wolf, R. L., Lepore, S. J., Vandergrift, J. L., Wetmore-Arkader, L., McGinty, E., Pietrzak, G., and Yaroch, A. L. (2008). Knowledge, barriers, and stage of change as correlates of fruit and vegetable consumption among urban and mostly immigrant black men. *Journal of the American dietetic associationi*, 108:1315–1322.

Wyse, R., Wolfenden, L., Campbell, E., Campbell, K. J., Waggers, J., Brennan, L., Fletcher, A., Bowman, J., and Heard, T. R. (2012). A cluster randomized controlled trial of a telephone-based parent interventin to increase preschoolers' fruit and vegetable consumption. *American journal of clinical nutrition*, 96:102–110.

Ye, X., Bhupathiraju, S. N., and Tucker, K. L. (2013). Variety in fruit and vegetable intake and cognitive function in middle-aged and older Puerto Rican adults. *British journal of nutrition*, 109:503–510.

List of Tables

Table 1: Characteristics of the sample

	n	%	Mean	SD	Cronbach's alpha
Age			51.6	16.4	
20-39	177	29.5			
40-59	202	33.7			
$\geq$ 60	221	36.8			
Gender					
Male	279	46.5			
Female	321	53.5			
Marital status					
Yes	432	72.0			
No	168	28.0			
Employment status					
Full-time employee	230	38.3			
Part-time employee	93	15.5			
Unemployed	277	46.2			
Education					
Low	383	63.8			
High	217	36.2			
Number of family members			2.8	1.4	
One	188	31.3			
Two	90	15.0			
Three or more	322	53.7			
Annual household income					
$<$3 million yen[1]	180	30.0			
3-4.99 million yen	180	30.0			
$\geq$5 million yen	240	40.0			
Distance to the nearest supermarket					
$\leq$0.8 km	202	33.7			
0.8-2.4 km	202	33.7			
$>$2.4 km	196	32.7			
Household's car ownership					
One car	296	49.3			
Two cars	193	32.2			
No cars	111	18.5			
Variety seeking tendency scale			22.4	5.9	0.77
Dietary knowledge scale			5.0	2.7	0.82
Meal-making self-efficacy scale			29.0	9.8	0.96
Health locus of control scale			19.1	3.5	0.87
Logical thinking disposition scale			40.3	8.4	0.91
Science literacy scale			2.5	2.4	0.90
Fruit and vegetable variety			22.5	11.6	

[1] As of June 2016, 2 million yen amounts to approximately 27 thousand US dollars.

Table 2: Multivariate regression analysis

Independent variables	Model 1			Model 2		
	B	$s.e.$	β[1]	B	$s.e.$	β
Socio-economic predictors						
Age						
20-39 (Reference)						
40-59	1.89	(1.09)	0.08	1.82	(1.08)	
≥ 60	6.06**	(1.37)	0.25	5.89**	(1.35)	
Gender						
Male (Reference)						
Female	−1.06	(1.06)	−0.05	1.07	(1.05)	
Marital status						
Yes	−1.89	(1.14)	−0.07	−1.88	(1.13)	
No (Reference)						
Employment status						
Full-time employee	0.48	(1.15)	0.02	0.20	(1.14)	
Part-time employee	−1.34	(1.29)	−0.04	−1.25	(1.28)	
Unemployed (Reference)						
Education						
Low (Reference)						
High	−0.30	(0.96)	−0.01	−0.05	(0.95)	
Number of family members						
One (Reference)						
Two	5.33**	(1.35)	0.21	5.10**	(1.34)	
Three or more	4.09**	(1.32)	0.18	3.90**	1.31	
Annual household income						
<3 million yen (Reference)						
3-4.99 million yen	−1.11	(1.03)	0.05	1.35	(1.10)	
≥5 million yen	−0.86	(1.08)	0.08	2.05	(1.17)	
Distance to the nearest supermarket						
≤ 0.8 km (Reference)						
0.8-2.4 km	1.26	(1.11)	−0.05	−1.07	(1.02)	
>2.4 km	1.85	(1.18)	−0.03	−0.69	(1.07)	
Household's car ownership						
Yes	2.13	(1.22)	0.07	2.45	(1.21)	
No cars (Reference)						
Perceptive predictors						
Critical thinking disposition scale	0.19**	(0.06)	0.14	0.20**	(0.06)	
Health locus of control scale	0.41**	0.12	0.12	0.77**	(0.17)	
Meal-making self-efficacy scale	0.05	(0.05)	0.04	0.03	(0.05)	
Science literacy scale	−0.04	(0.20)	−0.01	−0.04	(0.19)	
Nutrition knowledge scale	0.73**	(0.19)	0.17	0.79**	(0.19)	
Variety seeking tendency scale	0.23**	(0.08)	0.11	0.22**	(0.08)	
Interaction terms						
Health locus of control scale × female				0.72**	(0.23)	
Critical thinking disposition scale × Nutrition knowledge scale				0.05**	(0.02)	

[1] Standardized coefficients.
*: $p < 0.05$; **: $p < 0.01$.
Model statistics: $R^2 = 0.30$ and adjusted $R^2 = 0.28$

Table 3: Interaction terms that significantly improve the log

Interaction variable	B	$s.e.$	Δ (-2 log likelihood)
Critical thinking disposition scale $\times$ Nutrition knowledge scale	0.05**	0.02	6.85**
Critical thinking disposition scale $\times$ female	0.25**	0.10	6.68**
Health locus of control scale $\times$ female	0.72**	0.23	9.72**
Health locus of control scale $\times$ variety seeking scale	0.04*	0.02	5.02**
Health locus of control scale $\times$ marital status[1]	-0.50*	0.25	4.08*
Health locus of control scale $\times$ # of family members $= 2$	0.50*	0.25	4.15*

[1] Marital status $= 1$ if it is yes.
*: $p < 0.05$; **: $p < 0.01$.