Effects of Dietary Education on Food Consumption

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Selected Paper prepared for presentation at the Southern Agricultural Economics Association (SAEA) Annual Meeting, Jacksonville, Florida, February 3-6, 2018.

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Abstract

The Korean government's Dietary Education Basic Plan (DEBP) was designed to improve adolescents' eating habits, but there was a lack of performance indicators. This study analyzes the effect of dietary education on consumption of six major foods. This study used a 6-year data set from a survey conducted by the Korea Centers for Disease Control and Prevention (KCDC). Coarsened Exact Matching (CEM) and Propensity Score Matching (PSM) were employed. The results showed that dietary education significantly increased the frequency of breakfast, fruit, vegetable, and milk intake. However, it was not effective on carbonated beverage, and fast food consumption.

Keywords: Dietary Education, Dietary Education Basic Plan (DEBP), Adolescent, Coarsened Exact Matching (CEM), Propensity Score Matching (PSM)

JEL Codes : I12, I18, I28

I. Introduction

Healthy eating habits are important because they are associated with reduced risk for many cancers, coronary heart disease, stroke, and diabetes (Wechsler, et al., 2001). These habits are also bound up with a lower occurrence of overweight or obesity (Nicklas, et al., 2001). For these reasons, proper eating habits keep us healthy. Specially, good eating habits are important for adolescents. This is because an unhealthy diet during adolescence can have a negative effect on growth and development (Kelder, et al., 1994). Also, dietary habits and food preferences formed during adolescence affect dietary life in adulthood (Videon, 2003). For this reason, a lot of attempts have been made to use schools to promote healthful eating habits in adolescents (Van, et al., 2010). Adolescents spend much of their time at school, and the school environment is considered to have a strong effect on eating behaviors (Vereecken, et al., 2004). Therefore, it is very important to instill healthy dietary habits through continuous and systematic dietary education in schools.

A "Dietary Life Education Supporting Law" was enforced in Korea in 2009 to implement, manage, and supervise dietary education for all citizens at the national level. Based on this law, the Korean government implemented the 1st Dietary Education Basic Plan (DEBP) in 2010. This 1st plan ended in 2014, and a 2nd plan has been conducted since 2015 - this plan is set to end in 2019.

The 1st, and 2nd DEBP set three core values. These values are environment, health, and care. The 1st DEBP has four goals. The first goal is establishing infrastructures for dietary education. The second goal is to build an eco-friendly dietary life base. To attain this goal, the government promoted food mileage campaign, and implemented food waste reduction campaign. Also, the governments disseminated guidelines and recipes to reduce food waste. To expand the use of

local eco-friendly agricultural products, the government funded the school meal service centers, and increased facilities distributing local food directly. The third goal is to practice the Korean style food. To accomplish this goal, the government implemented a policy to strengthen the dietary education at home, kindergartens, schools, and local communities. This policy includes home diary dissemination, breakfast eating campaign, establishing dietary life schools, making vegetable gardens, and reflecting dietary education contents on textbooks. Another policy is to develop traditional food culture. This policy includes a program making a traditional soup, and designating Korean traditional food schools. The fourth goal is to create a social culture that people appreciate farmers and food. In order to achieve this goal, the government implemented the program that enables students to experience the farming and fishing villages. Food education fairs, and a diet camp was also held. The government established the 2nd DEBP based on the evaluation of the first plan. The 2nd DEBP has three goals. The first goal is activating dietary education at local level, and the second goal is strengthening governance. The third goal is expanding dietary education opportunity.

The government introduced two dietary education basic plans consecutively; however, there was no study to evaluate the 1st DEBP's effect and also were not enough performance indicators to measure the effect of dietary education policy. Most previous studies examined the effect on food consumption by specially designed dietary education. These dietary educations were implemented intensively in some schools for a short period of time. However, major developed countries implemented the diverse policies to improve adolescents' dietary habits. The UK introduced 'Cooking and Nutrition' curriculum in the elementary and middle schools. Through this policy, students learn how to grow farm products, and how to cook food. Italy implementd 'School and Food' program from 2009 to 2015. This plan was implemented to

encourage the consumption of fruits and vegetables, and to establish close relationships between producers and consumers. Also, this policy carried out for cultivating the ability to select healthy foods. France announced the 'National Program for Food' in 2010. This policy includes program providing adoescents with fruit. Also, France introduced the 'New Food Law for French School Cafeterias' to provide nutritionally balanced school meals in 2011. The US has a variety of meals programs including the National School Lunch Program (NSLP), the School Breakfast Program (SBP), the Fresh Fruit and Vegetable Program (FFVP), and the Speical Milk Program (SMP). These programs are run by the federal government. USDA operates Team Nutrition that is a program to support school meal programs and also provides various information about healthy food through MyPlate homepage.

Despite the introduction of school food policies worldwide, few large-scale nation-wide studies have been evaluated except the US and Europe (Jaime and Lock, 2009). Story (2009) studied the US Third School Nutrition Dietary Assessment (SNDA-III) including NSLP and SBP. Cullen, Watson et al. (2008) evaluated the effect of the Texas Public School Nutrition Policy(2005-2006) on middle school student lunchtime food consumption. Hirschman, Chriqui et al.(2013) evaluated school food and nutrition policy in the US over the past three decades. However, the scope of these studied are limited to the school meal programs. Van Cauwenberghe et al. (2010) reviewed the existing 13 European studies on the effectiveness of school-based interventions to promote adolescents' healthy diets. They found that an educational programme is likely to be effective to promote healthy nutrition of adolescents.

One point to be cautious on when analyzing the effects of dietary habits is that there might be differences between students participating in dietary education and those who are not – in other words, there might be a selection bias. In this case, even though there are differences in the effect

of dietary education between the students participating in this program and those who are not, it is difficult to distinguish whether these are due to differences in dietary education or other factors already existing between the two student groups. Therefore, if selection bias is not appropriately controlled, the results cannot be valid. In this regard, this study was carried out with the aim of reducing selection bias when analyzing effects of dietary education.

This study uses a 6-years data set from the online survey on youth health behavior conducted by Korea Centers for Disease Control and Prevention (KCDC). In order to reduce the selection bias between students who participated in dietary education and those who did not, both CEM and PSM are used. Through two matching methods, we will measure the causal effect of dietary education on food consumption. We will also inspect what of students' demographic and social characteristics have an impact on improving dietary habits. In this regard, this study will provide lessons for government policymakers who want to improve the health of adolescents through dietary education in schools.

II. The Theoretical Model

1. Selection Bias

Random variables that have connection with the effects of dietary education on food intake are denoted as $\boldsymbol{Y_1}$ and $\boldsymbol{Y_0}$, and the corresponding variables for individuals are defined as $\boldsymbol{Y_{1i}}$ and $\boldsymbol{Y_{0i}}$. $\boldsymbol{D_i}$ represents a dummy variable that indicates dietary education (getting a dietary education: 1, otherwise: 0). The below equation describes the effects of dietary education on food intake.

$$Y_i = \beta X_i + \alpha D_i + \varepsilon_i \quad (1)$$

The outcome observed for an individual is Y_i defined as

$$Y_i = D_i Y_{1i} + (1 - D_i) Y_{0i} \quad (2)$$

The treatment effect from participating in dietary education can be indicated as the difference between outcome obtained by an adolescent's participation in dietary education Y_{1i} and outcome from an identical student's non-participation Y_{0i}. This treatment effect $\mathbf{TE}_i$ is defined as

$$\mathbf{TE}_i = Y_{1i} - Y_{0i} \quad (3)$$

The ATT is the average effect of treatment on those subjects who ultimately received the treatment (Austin, 2011). ATT is defined as

$$\mathbf{ATT} = \mathbf{E}(\mathbf{Y_1} - Y_0|\mathbf{D} = \mathbf{1}) = \mathbf{E}(\mathbf{Y_1}|\mathbf{D} = \mathbf{1}) - \mathbf{E}(Y_0|\mathbf{D} = \mathbf{1}) \quad (4)$$

If we can find the Y_1 and Y_0 for an identical person, it is possible to estimate the treatment effect of dietary education. However, a person may not be in both two potential states at the same time (Heckman et al., 1997). For this reason, $\mathbf{TE}_i$ is not observed. So, we should use the average treatment effect (ATE), which is defined as

$$\mathbf{ATE} = \mathbf{E}(\mathbf{Y_1}|\mathbf{D} = \mathbf{1}) - \mathbf{E}(Y_0|\mathbf{D} = \mathbf{0}) = \mathbf{ATT} + \mathbf{E}(Y_0|\mathbf{D} = \mathbf{1}) - \mathbf{E}(Y_0|\mathbf{D} = \mathbf{0}) \quad (5)$$

In equation (5), $\mathbf{E}(Y_0|\mathbf{D} = \mathbf{1}) - \mathbf{E}(Y_0|\mathbf{D} = \mathbf{0})$ is a selection bias, and it is not likely to be zero. For this reason, the exact treatment effect cannot be estimated. Thus, the selection bias should be controlled.

In general, the selection bias is assumed not to exist due to a properly executed random assignment procedure. This assumption can be expressed as an ignorable treatment assignment (Rosenbaum and Rubin, 1983) or conditional independence assumption (Lechner, 1999). This

assumption is defined as

$$(\boldsymbol{Y_o}, \boldsymbol{Y_1}) \perp \mathbf{D} \mid \mathrm{X} \qquad (\mathbf{6})$$

However, dietary education was not randomly assigned to adolescents. For this reason, our study uses CEM to control for self-selection bias.

2. Coarsened Exact Matching (CEM)

There are many econometric models focusing on estimating average treatment effects under various sets of assumptions (Imbens, 2004). Among these, matching is a method to deal with a data set before estimating the sample average treatment effect on the treated (SATT) based on the matched data set (Iacus et al., 2009). Once a matched dataset is prepared, the causal effect is estimated by a simple difference in the outcome variable for the treated and control groups under ignorable treatment assignment (Iacus et al., 2011). Matching makes SATT less "model-dependent" and induces little bias and inefficiency (Ho, et al., 2007).

In this study, we use CEM as the matching method because of its many advantages over other matching methods, such as PSM (Iacus et al., 2012). To be specific, the widely used methods to reduce selection bias such as PSM do not guarantee any level of imbalance reduction in any given data set, so CEM provides a better balance (Iacus et al., 2012). In addition, using PSM requires a separate stage before matching to limit data to common support. CEM does not need the extra step. PSM is strongly affected by measurement errors, and CEM is much less heavily influenced by these problems. Two criteria are used to demonstrate the validity of the CEM. First, the descriptive statistics of the matching variables of the two groups are compared to determine whether the covariates of the matched sample are significantly different from those of the unmatched sample. Second, the imbalance test by (Iacus et al., 2009) is used, denoted as

$$\mathcal{L}_1(f, g) = \frac{1}{2} \sum_{l_1,\cdots l_k \in H(X)} |f_{l_1,\cdots l_k} - g_{l_1,\cdots,l_k}| \quad (7)$$

This test is based on the $\mathcal{L}_1$ difference between the multidimensional histogram of all the covariates in the treated group and in the control group. Let $H(X_1)$ be the set of distinct values made by binning on variable X_1. Then, the multidimensional histogram is created from the set of cells produced by the Cartesian product $H(X_1) \times ... \times H(X_k) = H(X)$. In equation (7), $f_{l_1,\cdots l_k}$ indicate the relative frequencies of the categorical variables for dietary education, while $g_{l_1,\cdots,l_k}$ indicate those for no dietary education. If the two distributions of data are completely separated, then $\mathcal{L}_1$ = 1. However, if the two distributions overlap exactly, then $\mathcal{L}_1$ = 0. After the imbalance test, matched samples are used to estimate the effect of dietary education on the frequency of food consumption, and OLS is employed. The empirical OLS regression model is defined as

$$Y_{ij} = \beta_0 + \beta_1 D_i + \beta_2 X_i + \varepsilon_i \quad (8)$$

Y_{ij} represents the frequency of adolescent i's consumption of food j for the last week based on the survey date. The data set includes frequency of intake of six kinds of food such as breakfast, vegetables, milk, fruit, fast food, and carbonated drinks. D_i is a dummy variable indicating whether an adolescent gets a dietary education. If adolescent i had at least one dietary education within the last year based on survey data, D_i equals to 1, and otherwise it is 0. X is a set of covariates, including individual i's characteristics such as sex, age, grade, residence area, household income level, allowance, and family members. ε_i denotes a random error term, and a normal distribution is assumed.

III. Data

1. Data

This study uses a 6-year data between 2011 and 2016, which includes 425,620 observations of an online survey on youth health behavior conducted by the KCDC. This survey has been conducted on about 70,000 people every year since 2005 to understand the trends of health behaviors of adolescents in Korea, and stratified cluster sampling was used for the sampling method. Prior to conducting the survey, selecting sample schools and classes was implemented. Also, registering the student status and the survey schedule was performed by an assistant teacher. On the day of the survey, the teacher led the students in the computer room of the school where the internet was available, and assigned them one computer per person. The assistant teacher allotted the seats randomly, and distributed a printed guide to each student. The teacher then explained the need of research and the method of participation using either a slide presentation or video. Following the presentation, students participated in the survey by accessing the homepage with the ID printed on the notice. The assistant teacher supervised the survey in accordance with the survey guidelines prohibiting the entrance of the homeroom teacher to the computer room, prohibiting viewing of students' computer screens except for by the students themselves, and not answering students' questions about the questionnaire. The whole process was conducted over 45-50 minutes. After completion of the survey, the assistant teacher reported the situation including the number of students who entered the computer room and the number of students who were in the computer room but did not participate in the survey through an online platform.

2. Variables and Descriptive Statistics

In this study, the variables included in empirical models to verify the effects of dietary education on food consumption are as follows. If a student experienced nutrition or dietary education in the last 12 months including education in the class, auditorium, or on broadcasting, it is classified as 1, and otherwise its value is 0. Dependent variables are as follows. The number of days of having breakfast in the last 7 days was divided into 0 to 7 days. Eating bread, sun-sik (natural raw food) or misut powder (powder of roast grain), rice gruel, and cereal is considered included for eating breakfast. Consuming only milk or juice was excluded. The frequency of having drinks (excluding fruit juice), vegetables (except kimchi), milk, fast food, and carbonated drinks within the last 7 days is divided as follows: ① I did not eat for the last 7 days, ② 1 ~ 2 times per a week, ③ 3 ~ 4 times per a week, ④ 5 ~ 6 times per a week, ⑤ 1 times a day, ⑥ 2 times a day, ⑦ 3 times a day.

A number of previous studies on food consumption behavior have found that socio-demographic factors such as age, sex, type of household, and income level affect food consumption behavior. Thus, we selected the residential area, city size, school type, family member composition, sex, grade, household financial status, residential type, allowances, and part-time job as covariates..

TABLE 1 HERE

Descriptive Statistics of the Variables on Table 1 show that frequency of participant intake in the past week was 4.56 times for breakfast, 8.13 times for vegetable, 4.40 times for fruit, 5.02 times for milk, 1.44 times for fast food and 2.03 times for carbonated beverage.

IV. Empirical Analysis and Results

The purpose of this study is to estimate the effect of dietary education on healthy food habits. However, direct comparison is not appropriate because of the presence of a selection bias exists. For this reason, our study was implemented through the following four steps. First, we used CEM to reduce the differences in the characteristics of explanatory variables existing between the treatment group and the control group. Second, we confirmed how the differences of characteristics between the treatment group and the control group are reduced by CEM. This was estimated through the L statistics derived from the imbalance test. Third, we estimated the marginal effect of dietary education on the frequency of food consumption by employing the matched sample. Finally, we used PSM such as Nearest-neighbor matching, Radius matching, and Stratification matching on the same data set to reinforce our results. The Stata 15.1 was used for estimations.

Table 2 presents the sample statistics of the independent variables by CEM. In the unmatched raw data, we can see that there are differences of characteristics between treatment group and control group. For instance, educated students have a tendency to be younger, male, to have a higher rate of residence in metropolitan areas, and to have higher economic status. A matched sample was composed based on the characteristics of students including their age, gender, residence area, family members, financial status, allowance, grade, scale of city they live in, type of school they go to, type of residence, and whether they have part time jobs. In the matched sample, adolescents are divided into 2 groups – a control group of 180,059 non-educated students and a treatment group of 137,670 educated students. In Table 2, we can find that the sample statistics of the matching variables of the two groups divided by the dietary education are almost equal. Moreover, multivariate $\mathcal{L}_1$ statistics indicating overall imbalance is conspicuously

reduced from 0.463 in the unmatched sample to less than 0.001 in the matched sample. This means that the matching was almost perfect, and that the imbalance has been improved to nearly zero by CEM. Therefore, our empirical study of the marginal effects of diet education on frequency of food consumption suggests valid results by minimizing the selection bias.

TABLE 2 HERE

Table 3 shows the results of using the ordinary least squares regression to estimate the marginal effects. To be specific, at the 1% significance level, the marginal effects of dietary education on frequency of breakfast, vegetables, fruits, milk, fast food, and carbonated drink are 0.13, 0.57, 0.36, 0.41, 0.05, and 0.04 respectively. However, there is a selection bias in these results.

TABLE 3 HERE

Table 4 shows estimates of the marginal effects on frequency of food intake using matched sample by CEM. We implemented the ordinary least squares regression to estimate the marginal effect.

TABLE 4 HERE

To be specific, at the 1% significance level, marginal effects of dietary education on breakfast, vegetables, fruits, milk, fast food, and carbonated drink are 0.16, 0.56, 0.38, 0.42, 0.05, and 0.03 respectively. This indicates that dietary education has a positive impact on the intake of breakfast, vegetables, fruits, and milk at the 1% significance level. However, these results also suggest that dietary education had little effect on decreasing the frequency of intake of fast food and carbonated beverages. Also, at the 1% significance level, the marginal effects of having a father on intake of breakfast, fruits, fast food, and carbonated drinks are 0.49, 0.34, -0.09, and -

0.15 respectively. In the case of vegetables and milk, the results are not significant. At the 1% significance level, the marginal effects of having mother on intake of breakfast, vegetables, fruits, milk, and carbonated drink are 0.65, 0.70, 0.78, 0.75, and -0.33 respectively, and the marginal effect on intake of fast food is -0.07 at the 10% significance level. These results show that the presence of parents has a significant positive influence on dietary habits.

The marginal effects of the lowest household financial status on breakfast, vegetables, fruits, milk, and carbonated drinks are -1.01, -2.02, -2.67, -1.74, and 0.29 respectively. This means that adolescents with low financial status intake less breakfast, vegetables, fruits, and milk than adolescents with higher financial status do. It also means that students with low financial status are more likely to consume more carbonated drinks than students with high financial status. The marginal effects of the part-time job on breakfast, vegetables, fruits, fast food, and carbonated drink are -0.73, -0.29, -0.42, 0.26, and 0.61 respectively. This indicates that adolescents that have part-time jobs intake less breakfast, vegetables, and fruits than do adolescents who do not have part-time jobs. It also means that adolescents that have part-time jobs intake more fast food and carbonated drinks than adolescents who do not have part-time jobs. Moreover, the results show that the marginal effect of fruit and milk consumption decreases as the grade increases at the 1% significance level.

We also implemented the PSM to check the robustness of our findings concerning the marginal effect of dietary education for adolescents on the frequency of food intake. We used three types of PSM methods, including Nearest-neighbor matching, Radius matching, and Stratification matching. Table 5 shows the estimated ATET and standard error derived by these PSM methods. The results of PSM analysis are very similar to those from CEM. This reinforces the finding that dietary education has a positive influence on the frequency of eating breakfast,

vegetables, fruit, and milk. Also, it is clear that dietary education does not affect the frequency of intake of fast food and carbonated beverages.

TABLE 5 HERE

V. Concluding Remarks

The Korean government's 1st DEBP, an initiative aimed to improve public health, was implemented from 2010 to 2014, and the 2nd DEBP is set to run from 2015 to 2019. One major component of the plan is dietary education for adolescents. However, there is a lack of adequate performance evaluation on whether the current dietary education actually improves adolescents' eating habits. Our study addresses this gap and helps to guide future health plans by examining the effect of current dietary education on adolescents.

The results showed that the number of breakfasts eaten by adolescents who received dietary education increased 0.16 times per week. Skipping breakfast may lead to weight gain over time and increase in risk factors for diabetes and cardiovascular disease (Giovannini et al., 2010). Therefore, it can be said that current education about eating habits has a positive effect not only on the health of the youth but also on their academic achievement. Adolescents who received dietary education were found to consume 0.56 more times vegetables a week. Vegetables are rich in water, vitamins, minerals, dietary fiber, and photochemicals, but low in energy density, and are useful for health improvement and disease prevention (Bhupathiraju and Tucker, 2011). Students who received dietary education were found to consume 0.38 more fruits a week. Therefore, current dietary education contributes to promoting adolescents' health of adolescents by promoting their intake of vegetables and fruits.

Adolescents who received dietary education increased their frequency of milk consumption

by 0.42 times per week. The frequency of drinking milk decreased as the grade increased from the first grade of middle school to the third grade of high school. It seems to be that the higher the grade level, the lower the participation rate in the school milk program. In the case of fruit, when the school grade increased, the frequency of eating fruit also decreased. The lack of calcium intake in Korean adolescents is related to the shortage of milk intake. Current dietary education can therefore be said to help improve adolescents' health by increasing their calcium intake. However, the education was not effective in reducing the frequency of fast food and soda consumption. It is necessary to improve the program to reduce the consumption of fast food and carbonated beverages.

This study showed that adolescents who had no father or mother had less favorable eating habits than others. Also, our study shows that adolescents who had lower financial status have unhealthier eating habits than other students. This finding is in line with the results of Deshmukh-Taskar et al.'s (2010) study, which shows that a higher percentage of adolescents with single parent or low household income skipped breakfast than did those with other household characteristics. Therefore, it is necessary for schools to take into account details of students' home environment, and take extra care to educate students if they live with single parents or have poor financial status. Adolescents with part-time jobs eat less breakfast, vegetables, fruits, and milk. They also consume fast food and carbonated drinks more frequently than those without part-time jobs. It may be that adolescence who work part-time are relatively busier than those who are not, and they eat fast food or carbonated beverages instead of a proper meal to save time.

These findings indicate that the current program of dietary education for adolescents is overall effective. However, it is necessary to improve the existing program so that it can more effectively reduce adolescents' intake of fast food and carbonated drinks. In addition, if a student

lives with single parents or has no parents, or if a student is from a lower income household, their school needs to pay more attention to that student’s dietary education. A policy to improve the eating habits of students with academic stress or part-time jobs is also needed. In order to achieve this, teachers in charge of school nutrition education programs need to know more about the situation of the student's family, economic status, and other personal situations. Counseling based on detailed information is needed for students who seem to require individual dietary education.

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Table 1. Descriptive Statistics of the Variables

Variable name	Variable description	Mean	SD	Min	Max
F_EDU	If experience nutrition & dietary education in school for last 1yr=1	0.40	0.49	0	1
Age	Age	15.00	1.75	12	18
Male	If male respondent=1	0.51	0.50	0	1
F_BR	Frequency of breakfast intake for past 7 days	4.56	2.62	0	7
F_VEG	Frequency of vegetable intake for past 7 days	8.13	6.90	0	21
F_FRUIT	Frequency of fruit intake for past 7 days	4.40	4.56	0	21
F_MILK	Frequency of milk intake for past 7 days	5.02	5.08	0	21
F_FASTFOOD	Frequency of fast food intake for past 7 days	1.44	1.66	0	21
F_SODA	Frequency of carbonated beverage intake for past 7 days	2.03	2.74	0	21
REGION_GG	If Gyeonggi area (Seoul, Gyeonggi, Incheon)=1	0.41	0.49	0	1
REGION_CC	If Chungcheong area (daejeon, Sejong, Chungnam, Chungbuk)=1	0.13	0.33	0	1
REGION_HN	If Honam area (Gwangju, Jeonnam, Jeonbuk, Jeju)=1	0.15	0.36	0	1
REGION_DG	If Daegu, Gueongbuk=1	0.11	0.31	0	1
REGION_DN	If Dongnam area (Gyeongnam, Busan, Ulsan)=1	0.16	0.37	0	1
REGION_GW	If Gangwon=1	0.04	0.18	0	1
CITY_B	If big city=1	0.52	0.50	0	1
CITY_M	If micropolitan=1	0.42	0.49	0	1
CITY_S	If small city=1	0.07	0.25	0	1
SCH_M	If boy’s school=1	0.17	0.38	0	1
SCH_F	If girl’s school=1	0.17	0.38	0	1
SCH_CO	If coed school=1	0.65	0.48	0	1
FATHER	If have father=1	0.96	0.20	0	1
MOTHER	If have mother=1	0.96	0.19	0	1
GF	If have grandfather=1	0.34	0.47	0	1
GM	If have grandmother=1	0.48	0.50	0	1
FC_H	If financial condition is high=1	0.08	0.26	0	1
FC_MH	If financial condition is middle high=1	0.25	0.43	0	1
FC_M	If financial condition is middle=1	0.48	0.50	0	1
FC_ML	If financial condition is middle low=1	0.16	0.36	0	1
FC_L	If financial condition is low=1	0.04	0.20	0	1
HOME_FAM	If live with family=1	0.95	0.21	0	1
HOME_REL	If live with relative=1	0.01	0.10	0	1
HOME_DOR	If live alone or live in lodging or dormitory=1	0.03	0.18	0	1
HOME_ORP	If live in orphanage=1	0.00	0.07	0	1
PARTT_JOB	If have a part-time job in the last 12 months=1	0.14	0.35	0	1

ALLWN	An average allowance per week	24,975	27,539	5,000	15,500
SCH_M1	If middle school 1st grade=1	0.16	0.37	0	1
SCH_M2	If middle school 2nd grade=1	0.17	0.37	0	1
SCH_H3	If high school 3rd grade=1	0.17	0.38	0	1
SCH_H1	If high school 1st grade=1	0.17	0.37	0	1
SCH_H2	If high school 2nd grade=1	0.17	0.37	0	1
SCH_H3	If high school 3rd grade=1	0.16	0.37	0	1

Table 2. Sample Statistics of the Explanatory Variables by CEM

	Raw Data (Unmatched Sample)		Matched Sample	
	F_EDU=0	F_EDU=1	F_EDU=0	F_EDU=1
Sample size	253,364	172,256	180,059	137,670
Variable	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
F_EDU	0 (0.00)	1 (0.00)	0 (0.00)	1 (0.00)
Age	15.30 (1.71)	14.46 (1.69)	14.37 (1.67)	14.37 (1.67)
Male	0.48 (0.50)	0.55 (0.50)	0.54 (0.50)	0.54 (0.50)
REGION_GG	0.41 (0.49)	0.43 (0.49)	0.47 (0.50)	0.47 (0.50)
REGION_CC	0.13 (0.34)	0.12 (0.33)	0.11 (0.31)	0.11 (0.31)
REGION_HN	0.15 (0.36)	0.15 (0.36)	0.14 (0.35)	0.14 (0.35)
REGION_DG	0.11 (0.31)	0.10 (0.31)	0.09 (0.29)	0.09 (0.29)
REGION_DN	0.16 (0.37)	0.17 (0.37)	0.16 (0.37)	0.16 (0.37)
REGION_GW	0.04 (0.19)	0.03 (0.17)	0.02 (0.15)	0.02 (0.15)
CITY_B	0.50 (0.50)	0.53 (0.50)	0.56 (0.50)	0.56 (0.50)
CITY_M	0.43 (0.49)	0.40 (0.49)	0.39 (0.49)	0.39 (0.49)
CITY_S	0.07 (0.25)	0.07 (0.25)	0.04 (0.20)	0.04 (0.20)
SCH_M	0.17 (0.38)	0.17 (0.38)	0.16 (0.37)	0.16 (0.37)
SCH_F	0.19 (0.39)	0.15 (0.36)	0.15 (0.36)	0.15 (0.36)
SCH_CO	0.64 (0.48)	0.67 (0.47)	0.69 (0.46)	0.69 (0.46)
FATHER	0.96 (0.20)	0.96 (0.19)	0.99 (0.10)	0.99 (0.10)
MOTHER	0.96 (0.19)	0.96 (0.19)	0.99 (0.08)	0.99 (0.08)

GF	0.32 (0.47)	0.36 (0.48)	0.36 (0.48)	0.36 (0.48)
GM	0.47 (050)	0.50 (0.50)	0.50 (0.50)	0.50 (0.50)
FC_H	0.07 (0.25)	0.09 (0.28)	0.07 (0.26)	0.07 (0.26)
FC_MH	0.24 (0.42)	0.27 (0.45)	0.29 (0.45)	0.29 (0.45)
FC_M	0.48) (0.50)	0.47 (0.50)	0.50 (0.50)	0.50 (0.50)
FC_ML	0.17 (0.37)	0.14 (0.34)	0.12 (0.33)	0.12 (0.33)
FC_L	0.05 (0.21)	0.03 (0.18)	0.02 (0.13)	0.02 (0.13)
HOME_FAM	0.95 (0.22)	0.96 (0.20)	0.99) (0.10)	0.99 (0.10)
HOME_REL	0.01 (0.10)	0.01 (0.09)	0.00 (0.02)	0.00 (0.02)
HOME_DOR	0.04 (0.19)	0.03 (0.16)	0.01 (0.09)	0.01 (0.09)
HOME_ORP	0.00 (0.06)	0.00 (0.07)	0.00 (0.01)	0.00 (0.01)
PARTT_JOB	0.16 (0.36)	0.13 (0.33)	0.08 (0.27)	0.08 (0.27)
ALLWN	26,222 (28,468)	23,142 (26,005)	18,767 (19,769)	18,767 (19,769)
SCH_M1	0.11 (0.32)	0.24 (0.43)	0.25 (0.43)	0.25 (0.43)
SCH_M2	0.14 (0.34)	0.21 (0.41)	0.22 (0.41)	0.22 (0.41)
SCH_M3	0.16 (0.37)	0.18 (0.38)	0.18 (0.39)	0.18 (0.39)
SCH_H1	0.18 (0.38)	0.15 (0.35)	0.14 (0.35)	0.14 (0.35)
SCH_H2	0.19 (0.40)	0.12 (0.33)	0.12 (0.32)	0.12 (0.32)
SCH_H3	0.21 (0.41)	0.10 (0.29)	0.09 (0.28)	0.09 (0.28)
Multivariate *L* statistics	0.463		<0.001	

Note: Numbers in parentheses are standard errors. F_EDU=0 denotes the control group.

Table 3. Estimates of the Marginal Effects on Frequency of Food Intake Using Unmatched Sample by CEM

Variable	Unmatched sample					
	Breakfast Marginal Effect (SE)	Vegetable Marginal Effect (SE)	Fruit Marginal Effect (SE)	Milk Marginal Effect (SE)	Fast food Marginal Effect (SE)	Carbonated beverage Marginal Effect (SE)
F_EDU	0.13*** (0.01)	0.57*** (0.02)	0.36*** (0.01)	0.41*** (0.02)	0.05*** (0.01)	0.04*** (0.01)
Age	0.05*** (0.01)	0.13*** (0.02)	0.01 (0.01)	-0.06*** (0.01)	0.05*** (0.00)	0.03*** (0.01)
Male	0.09*** (0.01)	0.30*** (0.03)	0.19*** (0.02)	1.78*** (0.02)	0.08*** (0.01)	0.61*** (0.01)
REGION_GG	-0.08*** (0.02)	0.07 (0.06)	0.31*** (0.04)	-0.24*** (0.04)	0.06*** (0.01)	0.16*** (0.02)
REGION_CC	-0.09*** (0.02)	0.04 (0.06)	0.15*** (0.04)	0.02 (0.05)	0.04*** (0.02)	0.20*** (0.03)
REGION_HN	-0.16*** (0.02)	0.04 (0.06)	0.14*** (0.04)	-0.11** (0.05)	0.09*** (0.02)	0.07*** (0.02)
REGION_DG	-0.00 (0.02)	0.08 (0.07)	0.10** (0.04)	0.20*** (0.05)	0.01 (0.02)	0.15*** (0.03)
REGION_DN	0.00 (0.02)	0.26*** (0.06)	0.14*** (0.04)	-0.24*** (0.05)	0.01 (0.02)	0.09*** (0.02)
CITY_B	0.02** (0.01)	-0.01 (0.02)	0.16*** (0.02)	-0.32*** (0.02)	0.01* (0.01)	-0.02* (0.01)
CITY_S	0.03* (0.02)	0.29*** (0.04)	-0.20*** (0.03)	0.26*** (0.03)	-0.07*** (0.01)	0.05*** (0.02)
SCH_F	-0.05*** (0.02)	-0.10** (0.04)	-0.05* (0.03)	0.04 (0.03)	-0.05*** (0.01)	-0.03* (0.02)
SCH_CO	-0.14*** (0.01)	-0.10*** (0.03)	-0.04** (0.02)	-0.24*** (0.02)	-0.03*** (0.01)	0.06*** (0.01)
FATHER	0.32*** (0.02)	0.31*** (0.06)	0.10*** (0.04)	-0.01 (0.04)	-0.10*** (0.01)	-0.16*** (0.02)
MOTHER	0.53*** (0.02)	0.50*** (0.06)	0.64*** (0.04)	0.35*** (0.04)	-0.12*** (0.01)	-0.26*** (0.02)
GF	0.01 (0.01)	0.20*** (0.03)	0.14*** (0.02)	0.12*** (0.02)	0.04*** (0.01)	0.02* (0.01)
GM	0.12*** (0.01)	0.09*** (0.03)	-0.04* (0.02)	0.02 (0.02)	-0.07*** (0.01)	-0.05*** (0.01)
FC_MH	-0.02 (0.02)	-0.88*** (0.04)	-1.00*** (0.03)	-0.75*** (0.03)	-0.13*** (0.01)	-0.18*** (0.02)

FC_M	-0.31***	-1.63***	-1.84***	-1.24***	-0.14***	-0.15***
	(0.02)	(0.04)	(0.03)	(0.03)	(0.01)	(0.02)
FC_ML	-0.55***	-1.64***	-2.38***	-1.36***	-0.20***	-0.11***
	(0.02)	(0.05)	(0.03)	(0.03)	(0.01)	(0.02)
FC_L	-0.90***	-1.76***	-2.47***	-1.42***	-0.04**	0.19***
	(0.02)	(0.07)	(0.04)	(0.05)	(0.02)	(0.03)
HOME_FAM	-0.58***	-1.28***	-0.89***	-1.05***	-0.81***	-0.70***
	(0.06)	(0.16)	(0.11)	(0.12)	(0.04)	(0.06)
HOME_REL	-0.76***	-1.82***	-0.89***	-0.87***	-0.38***	-0.39***
	(0.07)	(0.19)	(0.13)	(0.14)	(0.05)	(0.08)
HOME_DOR	0.19***	-0.17	-1.46***	-0.93***	-0.89***	-1.03***
	(0.07)	(0.17)	(0.11)	(0.12)	(0.04)	(0.07)
PARTT_JOB	-0.73***	-0.35***	-0.39***	-0.03	0.30***	0.67***
	(0.01)	(0.03)	(0.02)	(0.02)	(0.01)	(0.01)
ALLWN	-0.00***	-0.00***	0.00***	0.00	0.00***	0.00***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
SCH_M2	-0.03*	-0.34***	-0.20***	-0.44***	-0.02*	0.02
	(0.02)	(0.04)	(0.03)	(0.03)	(0.01)	(0.02)
SCH_M3	-0.08***	-0.44***	-0.31***	-0.68***	-0.04***	-0.03
	(0.02)	(0.05)	(0.04)	(0.04)	(0.01)	(0.02)
SCH_H1	-0.01	-0.87***	-0.78***	-1.52***	-0.07***	-0.23***
	(0.03)	(0.07)	(0.05)	(0.05)	(0.02)	(0.03)
SCH_H2	0.08**	-0.84***	-0.85***	-1.70***	-0.13***	-0.30***
	(0.03)	(0.09)	(0.06)	(0.06)	(0.02)	(0.03)
SCH_H3	-0.06	-0.75***	-0.83***	-1.80***	-0.16***	-0.37***
	(0.04)	(0.11)	(0.07)	(0.08)	(0.03)	(0.04)

Notes: 1. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.
2. Numbers in parentheses are standard errors.

Table 4. Estimates of the Marginal Effects on Frequency of Food Intake Using Matched Sample by CEM

Variable	Matched sample					
	Breakfast Marginal Effect (SE)	Vegetable Marginal Effect (SE)	Fruit Marginal Effect (SE)	Milk Marginal Effect (SE)	Fast food Marginal Effect (SE)	Carbonated beverage Marginal Effect (SE)
F_EDU	0.16*** (0.01)	0.56*** (0.02)	0.38*** (0.02)	0.42*** (0.02)	0.05*** (0.01)	0.03*** (0.01)
Age	0.06*** (0.01)	0.09*** (0.02)	-0.01 (0.02)	-0.08*** (0.02)	0.03*** (0.01)	0.02*** (0.01)
Male	0.08*** (0.01)	0.25*** (0.03)	-0.24*** (0.02)	1.83*** (0.02)	0.06*** (0.01)	0.56*** (0.01)
REGION_GG	-0.06* (0.03)	0.16* (0.09)	0.43*** (0.02)	-0.31*** (0.07)	0.02 (0.02)	0.16*** (0.03)
REGION_CC	-0.07** (0.03)	0.12 (0.09)	0.26*** (0.06)	-0.12* (0.07)	0.01 (0.02)	0.22*** (0.03)
REGION_HN	-0.15*** (0.03)	0.05 (0.09)	0.25*** (0.06)	-0.25*** (0.07)	0.04** (0.02)	0.09*** (0.03)
REGION_DG	0.01 (0.04)	0.19** (0.09)	0.22*** (0.06)	0.10 (0.07)	-0.02 (0.02)	0.15*** (0.03)
REGION_DN	0.02 (0.03)	0.31*** (0.09)	0.24*** (0.06)	-0.35*** (0.07)	-0.03 (0.02)	0.10*** (0.03)
CITY_B	0.02* (0.01)	0.03 (0.03)	0.17*** (0.02)	-0.38*** (0.02)	0.01 (0.01)	-0.03*** (0.01)
CITY_S	-0.03 (0.02)	0.28*** (0.06)	-0.20*** (0.04)	0.24*** (0.05)	-0.08*** (0.01)	0.08*** (0.02)
SCH_F	-0.03* (0.02)	-0.11** (0.05)	-0.13*** (0.04)	0.03 (0.04)	-0.04*** (0.01)	-0.05*** (0.02)
SCH_CO	-0.10*** (0.01)	-0.09** (0.04)	-0.06** (0.02)	-0.25*** (0.03)	-0.02*** (0.01)	0.03** (0.01)
FATHER	0.49*** (0.04)	0.09 (0.12)	0.34*** (0.08)	0.06 (0.09)	-0.09*** (0.03)	-0.15*** (0.04)
MOTHER	0.65*** (0.06)	0.70*** (0.16)	0.78*** (0.10)	0.75*** (0.11)	-0.07* (0.03)	-0.33*** (0.06)
GF	0.02 (0.01)	0.22*** (0.04)	0.15*** (0.02)	0.14*** (0.03)	0.02*** (0.01)	-0.01 (0.01)
GM	0.11*** (0.01)	0.07** (0.04)	-0.03 (0.02)	0.00 (0.03)	-0.04*** (0.01)	-0.01 (0.01)
FC_MH	-0.03* (0.02)	-1.01*** (0.05)	-0.98*** (0.03)	-0.79*** (0.04)	-0.07*** (0.01)	-0.10*** (0.02)

FC_M	-0.34***	-1.82***	-1.84***	-1.32***	-0.07***	-0.05***
	(0.02)	(0.05)	(0.03)	(0.04)	(0.01)	(0.02)
FC_ML	-0.62***	-1.87***	-2.45***	-1.46***	-0.11***	0.02
	(0.02)	(0.06)	(0.04)	(0.04)	(0.01)	(0.02)
FC_L	-1.01***	-2.02***	-2.67***	-1.74***	-0.00	0.29***
	(0.04)	(0.11)	(0.07)	(0.08)	(0.02)	(0.04)
HOME_FAM	-1.36***	-1.02	0.06	-2.22***	0.26	0.77**
	(0.37)	(1.00)	(0.67)	(0.74)	(0.22)	(0.37)
HOME_REL	-1.55***	-2.22*	-0.33	-1.79**	0.83***	1.05**
	(0.43)	(1.16)	(0.77)	(0.85)	(0.25)	(0.43)
HOME_DOR	-0.44	0.22	-0.54	-2.33***	0.09	0.29
	(0.38)	(1.01)	(0.67)	(0.74)	(0.22)	(0.37)
PARTT_JOB	-0.73***	-0.29***	-0.42***	-0.01	0.26***	0.61***
	(0.02)	(0.05)	(0.03)	(0.04)	(0.01)	(0.02)
ALLWN	-0.00***	-0.00***	0.00***	0.00***	0.00***	0.00***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
SCH_M2	-0.03*	-0.28***	-0.19***	-0.43***	-0.01	0.03**
	(0.02)	(0.04)	(0.03)	(0.03)	(0.01)	(0.02)
SCH_M3	-0.09***	-0.35***	-0.25***	-0.62***	-0.00	-0.02
	(0.02)	(0.06)	(0.04)	(0.05)	(0.01)	(0.02)
SCH_H1	-0.03	-0.73***	-0.68***	-1.40***	0.00	-0.20***
	(0.03)	(0.08)	(0.06)	(0.06)	(0.02)	(0.03)
SCH_H2	-0.10**	-0.63***	-0.74***	-1.58***	-0.04*	-0.28***
	(0.04)	(0.11)	(0.07)	(0.08)	(0.02)	(0.04)
SCH_H3	-0.08*	-0.45***	-0.72***	-1.66***	-0.06**	-0.34***
	(0.05)	(0.13)	(0.09)	(0.10)	(0.03)	(0.05)

Notes: 1. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.
2. Numbers in parentheses are standard errors.

Table 5. Estimated ATET of dietary education on frequency of food intake by PSM Methods

Matching method	Matched sample					
	Breakfast Marginal. Effect (SE)	Vegetable Marginal Effect (SE)	Fruit Marginal Effect (SE)	Milk Marginal Effect (SE)	Fast food Marginal Effect (SE)	Carbonated beverage Marginal Effect (SE)
Nearest-neighbor matching	0.12*** (0.01)	0.57*** (0.03)	0.36*** (0.02)	0.45*** (0.02)	0.06*** (0.01)	0.07*** (0.01)
Radius matching	0.14*** (0.01)	0.69*** (0.02)	0.50*** (0.02)	0.74*** (0.02)	0.04*** (0.01)	0.07*** (0.01)
Stratification matching	0.16*** (0.01)	0.64*** (0.02)	0.41*** (0.02)	0.55*** (0.02)	0.06*** (0.01)	0.08*** (0.01)

Notes: 1. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.
2. Numbers in parentheses are standard errors.