Journal of Rural Development 39(Special Issue): 89~112

MULTILEVEL ANALYSIS ON MOTHER'S NUTRITION LABEL USE AND CHILDREN'S PROPENSITY FOR BEING OVERWEIGHT

CHO SUNGJU*
LEE SANGHYEON**

Keywords
childhood obesity, multilevel probit, nutrition facts

Abstract
This study used a joint multilevel probit model to examine the determinants of nutrition label use and the relationship between mother's nutrition label use and children's propensity for being overweight. We found that the mother's concern for health, breakfast with family, mother's education level, as well as her employment status have impacts on how the mother uses nutrition labels. The estimation results also showed that the effect of siblings is significant while mother's nutrition label use and children being overweight are negatively correlated.

* Research Fellow, Korea Rural Economic Institute, Naju-si, Jeollanam-do, Korea.
** Research Fellow, Korea Rural Economic Institute, Naju-si, Jeollanam-do, Korea. Corresponding author. E-Mail: shlee@krei.re.kr.

Ⅰ. Introduction

Childhood obesity has been considered an important health policy issue. Accordingly, several studies examining the determinants of obesity have been carried out in recent years (Auld 2011; Coe and Zamarro 2011; Deb et al. 2011; Duffey et al. 2007; Ruhm 2012; Webbink et al. 2010; Wehby and Courtemanche 2012; Zhao and Kaestner 2010). A large number of studies have investigated the relation between maternal employment and childhood obesity (Anderson et al. 2003; Cawley and Liu 2012; Morrissey et al. 2011; Nie and Sousa-Poza 2014; Ruhm 2008); however, there are only a handful of studies examining the effects of parental behavior on childhood obesity (Anderson et al. 2003; Chang and Nayga 2011; Chen and Yang 2004; Gennetian et al. 2010).

Interestingly, several studies have illustrated the impacts of nutrition label use on adult health outcomes (Kim et al. 2000; Kim et al. 2001; Loureiro et al. 2012; Mandal 2010; Neuhouser et al. 1999; Satia et al. 2005; Teisl and Levy 1997); those studies found that use of nutrition label is significantly associated with dietary intakes. To our knowledge, however, Chang and Nayga's (2011) is the only study that examined the impacts of the mother's use of nutrition label on children's body mass index. They found that mothers' nutrition label uses are negatively related with the probability of their children being overweight, but the correlation is relatively weak.

"Nutrition label" is one of the most representative health-related information that consumers access at the time of purchase. Attention towards health has led to growing consumer and industry interest in nutrition labels. Since the regulation of nutrition labeling requires additional social costs, governments need to decide whether the provision of nutrition information should be voluntary or mandatory. Table 1 shows the current status of nutrition labeling regulations in many countries. United States adopted mandatory nutrition labeling in 1994, and now there are more than ten countries where nutrition labeling is mandatory. In addition, the European Union will designate nutrition labeling mandatory starting December 2016.

Table 1. Current status of nutritional labeling policy in various countries

Mandatory	Voluntary unless nutrition claim (or health claim) is made	Voluntary except for foods with special dietary uses	Always voluntary, but need to abide by formatting standards if nutrition labeling is used	No regulation
Australia New Zealand Canada United States Argentina Brazil Chile Paraguay Uruguay Hong Kong Malaysia (on most foods) Thailand (on some foods) South Korea (on some foods) Israel	All 27 European Union countries Switzerland China Colombia Costa Rica Ecuador El Salvador Mexico Brunei Indonesia Japan Philippines Singapore Thailand South Africa Tunisia Turkey	Bahrain Jordan Kuwait Oman Qatar United Arab Emirates Venezuela	Bolivia	Bahamas Barbados Bermuda Belize Dominican Republic Haiti Honduras Bangladesh Pakistan Cambodia Kenya Ghana Jamaica

Source: Hawkes (2010); updated by authors

Although nutrition labeling regulations have been introduced in many countries, obesity is constantly increasing. The World Health Organization (2015) indicated that worldwide obesity has increased by 11.4% between 2008 and 2014. Thus, public policymakers are faced with the question whether nutrition labeling regulations work (Variyam and Cawley 2006).

Many studies suggest that providing health-related information would lead consumers to switch to healthy products and thus, result in positive health outcome (Graham and Laska 2012, Guthrie et al. 1995, Kim et al. 2000, Neuhouser et al. 1999). As more countries are adopting mandatory regulation on nutrition labels, there are critical questions to consider. Do consumers really use nutrition labels and what makes them do so? In order to answer these questions, several previous studies examined the status and determinants of nutrition label use. Although some studies examined the determinants of nutrition label use, their findings were limited to socio-demographic information; therefore, available literature carries limited implications for policy makers. Accordingly, it still remains to be fully understood what factors lead consumers to use nutrition labels, as well as how policy makers can best respond. Therefore, this research focuses on the drivers for mothers' label use and the linkage between the mother's behavior and her children's probability of being overweight.

Child obesity in South Korea is growing rapidly. According to the Korea National Health and Nutrition Examination Survey (KNHANES), child obesity rates in Korea increased from 5.8% in 1997 to 9.6% in 2012. Although adult obesity rates in Korea are among the lowest in the Organization for Economic Co-operation and Development (OECD) member countries, child obesity rates are the 12th highest among the members (OECD 2015). Therefore, studies on child obesity are being actively pursued in Korea (Kim and Moon 2010, Kang et al. 2010, Yoo 2011, Byun and Kim 2012, Lee and Park 2013). Especially, child obesity might adversely impact children's physical health, self-esteem, social relation, and emotional well-being (Jeon and Gwak 2011, Kim et al. 2013, Seo and Lee 2014). Currently, nutrition labeling in Korea is required for only some food products (e.g., snacks, bread, noodles, and beverages). In Korea, homemakers are the main purchasers of food in a family (81.3% of total household food purchases), and 52.5% of homemakers use nutrition labels when they purchase food (Lee et al. 2007); therefore, nutrition label used by mothers may influence their children's obesity.

We conducted an empirical analysis using a national health survey in South Korea. For estimation, this study employed a multilevel random effects probit model for the correlation between mother's use of nutrition label and children being overweight. This study also examined the determinants that lead to a mother's use of nutrition label at the mother level and the probability of her children being overweight at the child level. The methodology that allows for mother-child correlation through random intercepts is distinctive from the two-stage model, used for the study on mother's use of nutrition label and children's likelihood of being overweight by Chang and Nayga (2011).

Our objectives in this research were (1) to examine the determinants of mother's use of nutrition label and children's obesity, (2) to determine whether children's propensity of being overweight is related to the mother's nutrition label use, and (3) to suggest useful policy tools that could enhance nutrition label use and thereby mitigate childhood obesity.

II. Methods

1. Model specification

In this study, a joint framework was used to find the relationship between mothers' nutritional label use and their children's probability of being overweight. Compared to Chang and Nayga (2011) who used a two-stage model including one child and one mother in a cluster, we employed a multilevel model using information on more than one child in a family. This approach provides a more robust methodology that takes into consideration commonly unobserved characteristics and sibling effects in a family, by analyzing both multilevel (mother-child) and intra-class (child-child) correlations. Furthermore, we explicitly addressed the factors Chang and Nayga (2011) did not consider: family meals and mother's obesity, the mother's employment status, and physical activity. The additional covariates have implications on how regulations may target specific groups.

Our framework is exhibited graphically in Figure 1. This framework has simultaneity in that childhood obesity enters the probability of mother's nutrition label use and mother's nutrition label use enters the probability of children being overweight. Thus, we presume that the mother's label use can affect her children's rate of being overweight through unobservable factors and vice versa. Unobservable factors may include any kinds of maternal characteristics, child heterogeneity, and/or any variables omitted from the model. At the mother level, the factors may include the mother's work intensity and the father's attentive efforts towards child's diet habits, and at the child level, the unobservable factors may include individual characteristics. The unobservable factors can be approximated using the random-effects term included in our model.

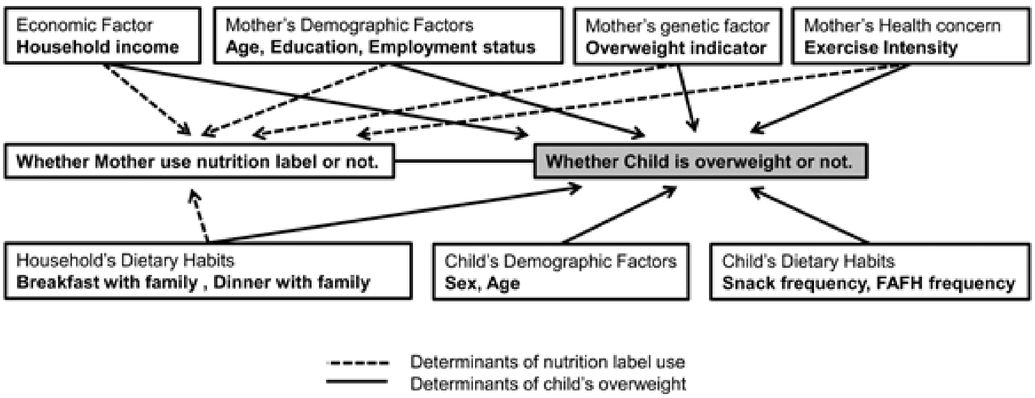
Based on the findings of the previous studies (Chang and Nayga 2011; Drichoutis et al. 2009; Loureiro et al. 2012; Nayga et al. 1998), a system of equations is generated to represent the relationship, including one equation in which the mother's label use is the dependent variable, and the other equation for each child in which the indicator of being overweight is the dependent variable.

Following (albeit in a simplified form) the empirical model used by Drichoutis et al. (2008), we included covariates on label use by mothers. The economic factor (household income), the mother's demographic factors (age, education, and employment status), mother's genetic factors (obesity indicator), mother's concern for health (exercise intensity), and the household's dietary habits (breakfast with family and dinner with family, included based on the results of Kageyama et al. (2007)) are explanatory variables in the mother's nutrition label use equation. For the equation involving children, the child's demographic factors (sex and age), child's dietary habits (snack frequency and food away from home [FAFH] frequency), along with all explanatory variables used in the mother's nutrition label use equation are added as explanatory variables.

Motivated by the working hours suggested by Drichoutis et al. (2008), we included employment status to reflect time availability and interests in health among the factors. Other demographic and economic factors are used in a similar manner as in previous studies (Chang and Nayga 2011; Drichoutis et al. 2009; Loureiro et al. 2012; Nayga et al. 1998). Drichoutis et al. (2008) found that overweight individuals are more likely to use nutritional labels than non-overweight ones. They also showed significant effects of age, slight effects of education level, and insignificant effects of household income on nutritional label use. Based on the findings of Lee (1999) and Yeo and Kim (2010), which indicate that respondents who have higher health concerns generally exercise more, we included an exercise intensity indicator to assess the attitude of mothers concerning their own health.

The explanatory variables specified in the equation for overweight children are based on variables adopted from previous studies. Anderson et al. (2003) and Takahashi et al. (1999) found that body mass index and demographic factors of mothers (e.g., household income, age, education and employment status) had significant effects on their children's obesity. Studies have also shown that parents' physical activity and dietary patterns are significantly related to children being overweight (Birch and Davison 2001; Davison and Birch 2002; Vanhala et al. 2009). In addition, studies have found a positive correlation between a child's dietary behaviors, (e.g., snack consumption and the frequency of eating away from home) and the probability of being overweight (Alviola et al. 2014; Mancino et al. 2009).

Figure 1. Child obesity model with the effects of label use



A two-level random effects probit model was used to examine the interaction between the probability of mother's nutrition label use (level 2) and the probability of children being overweight (level 1). We revised the model introduced by Francavilla et al. (2013). The level-2 (mother level) equation is assumed to have a random effects structure, which allows for the correlation between mother and children residuals. This correlation may imply joint nature of mother's nutrition label use regarding children's propensity for being overweight. We can also get within-class correlation, which implies the residual correlation of children's probability of being overweight among their siblings.

Let $j = 1, 2, \ldots, J$ indicate mothers and $i = 1, \ldots, n_j$ denote the children of mother j. Let the observed mother's use of nutrition label be $y_j^{(2)}$ (1 = use of nutrition label; 0 = otherwise) and the observed overweight status of each of her children be y_{ij} (1 = overweight; 0 = otherwise). Superscripts within parentheses denote the level of the variables such that (2) indicates the level 2 (mother level) and no superscript implies the level 1 (child level). Then the probability of mother j's nutrition label use is assumed as:

$$(1) \qquad y_j^{(2)} = \begin{cases} 1 & \text{if } y_j^{(2)*} > 0 \\ 0 & \text{otherwise} \end{cases}$$

and the probability of mother j's child i being overweight is assumed as:

$$(2) \qquad y_{ij} = \begin{cases} 1 & \text{if } y_{ij}^{*} > 0 \\ 0 & \text{otherwise} \end{cases}$$

where $y_j^{(2)*}$ and y_{ij}^* are the latent variables for mother j and her child i, respectively. We assume that the joint model for the probabilities has the form of two level equations following Francavilla, Giannelli and Grilli (2013):

(3) $y_j^{(2)*} = \alpha^{(2)} + \beta^{(2)} x_j + \zeta_j^{(2)} + \varepsilon_j^{(2)}$ (mother level)

(4) $y_{ij}^* = \alpha + \beta x_j + \gamma z_{ij} + \zeta_j + \varepsilon_{ij}$ (child level)

where z_{ij} is the vector of child level covariates (child's age, gender and food consumption behavior), x_j is the vector of mother level covariates (household income, mother's age, education, meals with family, exercise, obesity and employment status), and $\alpha^{(2)}$ and α are mother-specific and child-specific constants. Note that mother level covariates are included in the child level equation since the model assumes that the mother's characteristics affect children's probability of being overweight. We will discuss the assumptions on the random effects and error terms below.

The model assumes that the random intercepts $(\zeta_j^{(2)}, \zeta_j)$ are independent among mothers and normally distributed such that $\zeta_j^{(2)} \sim N(0, \psi_{22})$ and $\zeta_j \sim N(0, \psi_{11})$ where $Cov(\zeta_j^{(2)}, \zeta_j) = \psi_{21} = \psi_{12} = Cov(\zeta_j, \zeta_j^{(2)})$. The variance of the random intercept $\zeta_j^{(2)}$ is fixed at a unity ($\psi_{22} = 1$) to make the equations identifiable. The mother level random intercept ζ_j is indifferent for siblings within a family by construction. We also assume that the error terms are independent and identically distributed such that $\varepsilon_j^{(2)}, \varepsilon_1, \ldots, \varepsilon_{n_j} \sim N(0,1)$ and $Cov(\varepsilon_j^{(2)}, \varepsilon_{ij}) = Cov(\varepsilon_{i'j}, \varepsilon_{ij}) = 0 \; (i' \neq i)$. Additionally, we assume that the random intercepts (ζ) are independent of any error terms (ε). Under these assumptions the child level equation (3) becomes a random effects probit model because the random intercept at mother level differs across mothers, and ε_{ij} differs within the same mother j.

The mother level equation (4) can be written as a single error term $\zeta_j^{(2)} = \zeta_j^{(2)} + \varepsilon_j^{(2)}$ where both $\zeta_j^{(2)}$ and $\varepsilon_j^{(2)}$ vary between mothers. Using this decomposition, we estimated a correlation between mother and child equations, since implementing $\zeta_j^{(2)}$ allows the random effects model enable correlated random effects. For the estimation, we used a user-written Stata command, gllamm, which was developed by Rabe-Hesketh et al. (2005). This command uses, numerically, a Newton-Raphson method to maximize the likelihood function with an adaptive Gauss-Hermite quadrature[1]. The simultaneous system equation structure of this model permits a correlation between the unobservable factors pertaining to the probabilities of mother's label use and whether a child is overweight. Furthermore, this model considers the correlation between siblings under the same mother through the mother level random effects term. Note that, in the multilevel probit model, the effect of a covariate for children being overweight is conditional on the mother's covariates, rather than marginal, as discussed in the study by Francavilla et al. (2013). If there is a high correlation among siblings, the random effects model would be more appropriate than the standard probit model. The multilevel model may not make a huge difference compared to the simple model when the number of children in a family is relatively small, but at least it allows us to control more unobservable characteristics among children than otherwise.

2. Data and variables

The survey data for this study pertaining to mothers and children were drawn from the Fourth Korea National Health and Nutrition Examination Survey (KNHANES IV) from 2008 to 2012 (Korea Centers for Disease Control and Prevention, 2007, 2008, 2009). KNHANES is a national survey conducted by Korea Centers for Disease Control and Prevention; it consists of a health examination, health interview, and nutrition survey. We used data on education, income, diet and other demographic information from the face-to-face interviews and height, weight and other health conditions from the physical examinations over the period from January 2007 to December 2009. KNHANES is stratified into 16 provisional regions and again into age groups proportional to the corresponding sizes of population. Thus, the surveyed samples can be combined across years with appropriate weights. Overall, KNHANES is similar to the US NHANES in terms of survey design and methodology. KNHANES also provides information about the mother–child relationship that is essential for our multilevel model that NHANES does not provide.

Since our data have a multi-period cross-sectional structure, it is hard to differentiate the family's fixed effects over time. As indicated in Francavilla et al. (2013), the two-level model cannot assess whether label use results in being overweight among children or vice versa, but under the assumption that label use by mothers and being overweight of children are determined simultaneously, we can

[1] The estimation involves 7 quadrature points for each random effects term for accuracy and speed.

examine whether the covariates at the different levels have similar effects on the two outcomes, without further assuming which occurs first.

Since our aim was to examine the relationship between nutrition label use and children's probability of being overweight, each child's body mass index (BMI) was calculated using her/his weight and height (kg/m2) from the KNHANES database. For adults, a BMI of 25 or more is considered to indicate overweight and a BMI of 30 or more is considered obese according to the recommended international BMI classification by WHO (WHO Expert Consultation 2004). However, children's BMI is classified differently by their sex and age based on the distribution of the population, where a BMI greater than the 85th percentile is considered as overweight and a BMI greater than the 95th percentile is considered as obese. Table 2 shows criteria for overweight and obesity for children in Korea (Korea Centers for Disease Control and Prevention and the Korean Pediatric Society 2007). The criteria are not increasing in a linear manner by ages and we find that in general the criterion for boys is higher than that for girls.

Table 2. Criteria that indicate underweight, overweight and obesity for Korean children

Age	Boy's BMI			Girl's BMI		
	Underweight	Overweight	Obese	Underweight	Overweight	Obese
2	14.33	19.15	-	14.12	18.94	-
3	14.15	18.40	-	13.92	18.19	-
4	14.01	18.34	-	13.76	18.03	-
5	13.91	18.78	-	13.64	18.33	-
6	13.87	17.86	19.59	13.59	17.48	18.96
7	13.93	18.86	20.93	13.63	18.27	20.05
8	14.06	19.80	22.13	13.77	19.05	21.05
9	14.27	20.76	23.34	14.01	19.88	22.09
10	14.57	21.71	24.48	14.33	20.71	23.08
11	14.93	22.57	25.00	14.73	21.51	23.99
12	15.35	23.32	25.00	15.20	22.22	24.77
13	15.82	23.93	25.00	15.71	22.83	25.00
14	16.32	24.40	25.00	16.25	23.31	25.00
15	16.83	24.74	25.00	16.78	23.67	25.00
16	17.33	24.95	25.00	17.27	23.89	25.00
17	17.80	25.08	25.00	17.68	23.99	25.00
18	18.20	25.18	25.00	17.96	23.98	25.00

Source: Korea Centers for Disease Control and Prevention and the Korean Pediatric Society (2007)

We extracted a sample of 3298 children, aged 2 – 12 years and their 2112 mothers from the KNHANES database. The average number of children per mother is 1.56. In the survey, the mothers were asked: "When you buy food items, do you read the nutrition label?" (Translated by the authors) According to the questionnaire, mothers are classified as users of nutrition label or non-users of nutrition label.

As mentioned above, for the mother equation (3), mother's age, education levels [1=elementary school graduate (base); 2=middle school graduate; 3=high school graduate; 4=college graduate and above], household income quartile [1st (base); 2nd; 3rd; and 4th quartiles], number of children aged 2 – 12 in a family, breakfast with family, dinner with family, intensity of exercise activity, overweight indicator, and employment status were measured. For example, Household income: 2nd quartile indicates that the level of household income is in the second quartile income class. To reflect the mother's attitude towards health concerns, an exercise intensity[2] indicator was included. Summary statistics for each variable of the mother equation (3) are shown in Table 3.

Table 3. Sample means of mother level covariates by mother's behavior (n = 2112)

Variables	Using label		Not using label	
	Mean	SD	Mean	SD
Household income: 2nd quartile	0.239	(0.427)	0.261	(0.440)
Household income: 3rd quartile	0.357	(0.479)	0.378	(0.485)
Household income: 4th quartile	0.358	(0.480)	0.293	(0.455)
Number of children aged 1-12	1.643	(0.619)	1.647	(0.631)
Mother's age	36.713	(4.871)	36.687	(5.028)
Family breakfast	0.747	(0.435)	0.681	(0.466)
Family dinner	0.911	(0.285)	0.894	(0.308)
Mother's education level: Middle	0.046	(0.209)	0.051	(0.221)
Mother's education level: High	0.476	(0.500)	0.564	(0.496)
Mother's education level: College and above	0.474	(0.500)	0.358	(0.480)
Mother's exercise intensity	1.173	(1.593)	1.022	(1.481)
Mother being overweight	0.226	(0.419)	0.211	(0.408)
Mother's employment status	0.414	(0.493)	0.471	(0.499)
Number of observations	**1003**		**1109**	

Note: SD indicates sample standard deviations whose values are in parentheses.

[2] Intensity of exercise activity was calculated as the weighted average of hours of walking (1), modest exercise (2) and intensive exercise (3).

Summary statistics for each variable of the child equation (4) are shown in Table 4. As we mentioned above, each child's probability of being overweight is classified as overweight or not-overweight. The KNHANES survey also provides some information on children's lifestyle. For example, children participating in the study were asked questions such as: "How often did you exercise last week?" (Translated by the authors) However, the answers to those questions inform us of only their very recent activities, which are not appropriate for our study. Thus, among the other annual basis questions, we included children's sex, age, snack frequency and frequency of food away from home (FAFH) as shown in Figure 1. The KNHANES survey also provides information on a respondent's dietary habits. For example, respondents were asked questions such as "In the past year, on average, how often did you eat out?" (Translated by the authors) Respondents chose one of five predetermined frequencies from "rarely" to "quite frequently". The respondents were also asked questions such as "In the past year, did you mostly have dinner with your family?" (Translated by the authors). In our sample, 47% of mothers used the nutrition label and 15% of children were considered overweight or obese. The nutrition label users showed, on average, slightly higher levels of the income quartile, breakfast with family, dinner with family, education level, exercise intensity, and overweight but lower levels of employment status and number of children in a household.

Table 4. Sample means of child level covariates by children's probability of being overweight including mother level covariates (n = 3298)

Variables	Overweight		Not overweight	
	Mean	SD	Mean	SD
Child's sex (0=boy; 1=girl)	0.444	(0.497)	0.482	(0.500)
Child's age	8.307	(2.625)	6.948	(3.135)
Household income: 2nd quartile	0.259	(0.439)	0.263	(0.440)
Household income: 3rd quartile	0.351	(0.478)	0.374	(0.484)
Household income: 4th quartile	0.315	(0.465)	0.308	(0.462)
Number of children aged 1-12	1.805	(0.672)	1.879	(0.643)
Mother's age	37.388	(4.591)	36.274	(4.524)
Family breakfast	0.723	(0.448)	0.720	(0.449)
Family dinner	0.892	(0.311)	0.919	(0.273)
Mother's education level: Middle	0.052	(0.223)	0.042	(0.200)
Mother's education level: High	0.584	(0.493)	0.529	(0.499)
Mother's education level: College and above	0.333	(0.472)	0.418	(0.493)
Mother's exercise intensity	1.255	(1.621)	1.086	(1.537)

(continued)

Variables	Overweight		Not overweight	
	Mean	SD	Mean	SD
Mother being overweight	0.351	(0.478)	0.201	(0.401)
Mother's employment status	0.486	(0.500)	0.428	(0.495)
Child's snack frequency	3.711	(0.926)	3.835	(0.892)
Child's food away from home frequency	3.110	(0.626)	3.086	(0.634)
Number of observations	498		2800	

Note: SD indicates sample standard deviations whose values are in parentheses.

III. Results and discussion

Mother and child equations were fitted simultaneously using the gllamm Command of Stata to estimate the covariance between unobservable factors related to mother and children (ψ_{21}). This process allows us to derive the correlation between the unobservable factors at mother and child levels. We estimated variance, covariance, and correlation of random effects of the following as discussed by Francavilla et al. (2013):

(5) $$Var(y_j^{(2)*}|x_j) = Var(\zeta_j^{(2)}) + Var(\varepsilon_j^{(2)}) = 1+1=2;$$

(6) $$Var(y_{ij}^{*}|x_j, z_{ij}) = Var(\zeta_j) + Var(\varepsilon_{ij}) = \psi_{11}+1;$$

(7) $$Cov(y_{ij}^{*}, y_{i'j}^{*}|x_j, z_{ij}, z_{i'j}) = Cov(\zeta_j, \zeta_j) = Var(\zeta_j) = \psi_{11};$$

(8) $$Cor(y_{ij}^{*}, y_{i'j}^{*}|x_j, z_{ij}, z_{i'j}) = \psi_{11}/(\psi_{11}+1);$$

(9) $$Cov(y_j^{(2)*}, y_{ij}^{*}|x_j, z_{ij}) = Cov(\zeta_j^{(2),}\zeta_j) = \psi_{21};$$ and

(10) $$Cor(y_j^{(2)*}, y_{ij}^{*}|x_j, z_{ij}) = \psi_{21}/\sqrt{2(\psi_{11}+1)}.$$

Table 5 shows the results of the maximum likelihood estimation of the child equation (4). In the child equation, all siblings from the same mother have the same random intercept ζ_j. The random effect ζ_j represents unobserved elements at the mother level. If the residual correlation between siblings' probabilities is high, it justifies employing a multilevel analysis. High intra-class correlation within data pertaining to a mother means that siblings' weights are strongly related. The variance of the child random effects ψ_{11} is estimated to be significant at 0.456. Thus, an increase in one value of the standard deviation of the random effects leads to an increase by 0.675 in the probability of a child being overweight. This standard deviation was used to calculate intra-class correlation coefficients (ICC) such that the mother's probability of her children being overweight yielded 0.313.

In the child equation estimates, the child level estimates show that girls have a lower probability of being overweight, and that the child's age has a positive impact with decreasing rate on the probability of being overweight. Also, we found that the effects of the mother's education level and being overweight are significant. However, it is intrinsically difficult to interpret the estimates directly, because the coefficients in nonlinear models do not imply partial effects, unlike in the case in linear regressions.

Accordingly, we also estimated the average partial effects (APE) to make the results easier to interpret. In a probit model, APE is calculated as the mean of partial effects evaluated at each observation with the k-th covariate varying by one unit, $APE_k \equiv dE(y_j^{(2)*}|x_j, z_{ij})/dx_k = n^{-1}\Sigma_{j=1}^{n}[\Phi(\beta x + \beta_k) - \Phi(\beta x)]$ for discrete covariates and $AME_k = \beta_k n^{-1}\Sigma_{j=1}^{n}\phi(\beta x)$ for continuous covariates in the mother's equation, where ϕ is the standard normal probability density function. It is similarly evaluated in the child's equation.

We can see that the average partial effects have the same signs as the coefficients for each covariate, but the APE also has implications for the magnitude of change in probability due to the one unit change of the relevant covariate. Thus, we can compare the effects of covariates and consider the implications on how the predicted probability would change. For instance, the probability of child A being overweight increases by 0.113 when his/her mother is overweight but if the mother is an elementary school graduate, then the probability decreases by -0.140 compared to children having a middle school graduate mother. Thus, compared to child A having a mother who is overweight and a middle school graduate, child B having a mother who is not overweight and an elementary school graduate has less probability of being overweight by 0.028. This relationship over a child's age can be shown as A being (2, 1) and B being (1, 0) in Figure 2, in which the dashed and solid lines indicate the elementary school and middle school graduates, respectively.

Table 5. Estimates of cases where a child is overweight in the child equation and the mother uses nutrition labels in the mother equation

Covariates	Coefficients	SE	APE	APE SE
Child equation				
Child's sex (0=boy; 1=girl)=1	- 0.119*	(0.067)	- 0.021*	(0.012)
Child's age	0.413***	(0.067)	0.013***	(0.002)
Child's age squared	- 0.020***	(0.004)		
Child's snack frequency	0.029	(0.040)	0.005	(0.007)
Child's food away from home frequency	- 0.068	(0.057)	- 0.012	(0.010)
Household income: 2nd quartile	- 0.157	(0.157)	- 0.029	(0.030)
Household income: 3rd quartile	- 0.138	(0.156)	- 0.026	(0.030)
Household income: 4th quartile	- 0.094	(0.160)	- 0.018	(0.031)
Number of children aged 1-12	- 0.147**	(0.060)	- 0.026**	(0.010)
Mother's age	- 0.064	(0.083)	- 0.003	(0.002)
Mother's age squared	0.001	(0.001)		
Family breakfast=1	0.063	(0.081)	0.011	(0.014)
Family dinner=1	- 0.126	(0.123)	- 0.023	(0.024)
Mother's education level: Middle	- 0.635**	(0.298)	- 0.141*	(0.075)
Mother's education level: High	- 0.551**	(0.267)	- 0.127*	(0.073)
Mother's education level: College and above	- 0.629**	(0.272)	- 0.140*	(0.074)
Mother's exercise intensity	0.025	(0.022)	0.004	(0.004)
Mother being overweight=1	0.555***	(0.084)	0.113***	(0.019)
Mother's employment status=1	0.033	(0.073)	0.006	(0.013)
Constants of child equation	- 0.563	(1.532)		
Mother equation				
Household income: 2nd quartile	0.152	(0.187)	0.049	(0.060)
Household income: 3rd quartile	0.082	(0.185)	0.027	(0.060)
Household income: 4th quartile	0.256	(0.188)	0.084	(0.061)
Number of children aged 1-12	- 0.032	(0.067)	- 0.011	(0.022)
Mother's age	0.031	(0.082)	0.002	(0.003)
Mother's age squared	- 0.000	(0.001)		
Family breakfast	0.250***	(0.090)	0.082***	(0.029)
Family dinner	0.026	(0.140)	0.009	(0.045)
Mother's education level: Middle	1.401***	(0.417)	0.354***	(0.080)
Mother's education level: High	1.327***	(0.389)	0.330***	(0.058)
Mother's education level: College and above	1.705***	(0.394)	0.456***	(0.060)
Mother's exercise intensity	0.061**	(0.026)	0.020**	(0.008)
Mother being overweight	0.157	(0.096)	0.051	(0.031)
Mother's employment status	- 0.202**	(0.082)	- 0.066**	(0.027)
Constants of mother equation	- 2.562*	(1.512)		
Number of observations (Child)	3298			
Number of observations (Mother)	2112			
$\hat{\psi}_{11}$	0.456***	(0.137)		
Estimated intra-class correlation coefficient (ICC)	0.313***	(0.065)		
$\hat{\psi}_{21}$	- 0.113*	(0.063)		
Estimated correlation between unobservable factors	- 0.067*	(0.037)		

Note: APE indicates the average estimates of partial effects for each covariate. SE indicates standard errors of the estimates, which are shown in parentheses on the right of the relevant coefficients and APEs. ***, **, and * indicate statistical significance at the levels 1%, 5%, and 10%, respectively. $\hat{\psi}_{11}$ indicates the estimated variance of the child random effects. $\hat{\psi}_{21}$ indicates the estimated covariance of mother-child unobservable factors. A likelihood-ratio (LR) test comparing our model with the model without ψ_{21} was conducted (LR chi-square = 24.85, p = 0.0000). The LR test result implies that our model is in favor of the alternative model, and $\hat{\psi}_{21}$ and the estimated correlation between the unobservable factors are significant.

As shown in Table 5, the average partial effects of mother's education level are very similar among middle school, high school and college graduates compared to the elementary school graduates. This implies that policy makers need to focus on mothers who are given less education to mitigate childhood obesity. Furthermore, the mother's propensity for being overweight is likely to result in her children's probability of being overweight. As discussed in studies by Danielzik et al. (2004), Sekine et al. (2002), and Wu and Suzuki (2006), the positive relationship may be linked to epidemiological factors and parental diet behaviors. In addition, a contrasting probability of being obese or overweight is observed based on the number of siblings. In other words, as the number of siblings increases, the child has lower probability of being overweight. This conforms to the existing observations that only children have a higher risk of being overweight and increasing the number of siblings reduces the risk of obesity as discussed in Haugaard et al. (2013) and Wang et al. (2007).

Figure 2. Predicted probability of child being overweight over child's age by mother's education level and being overweight

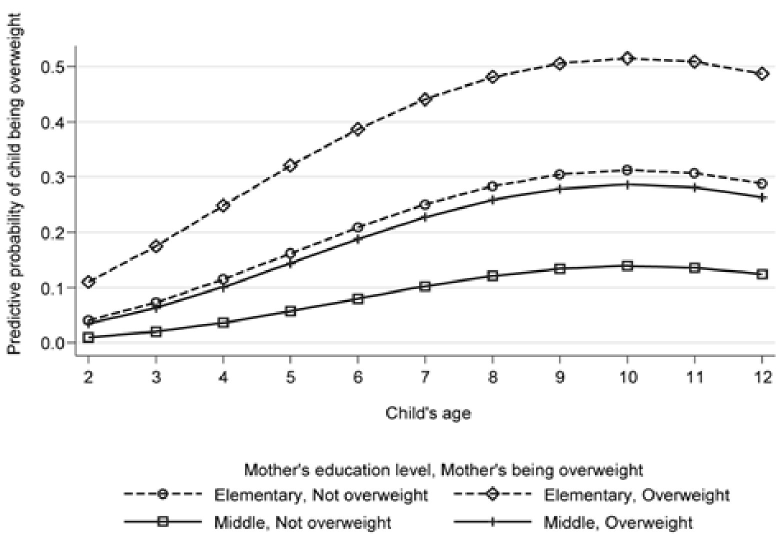
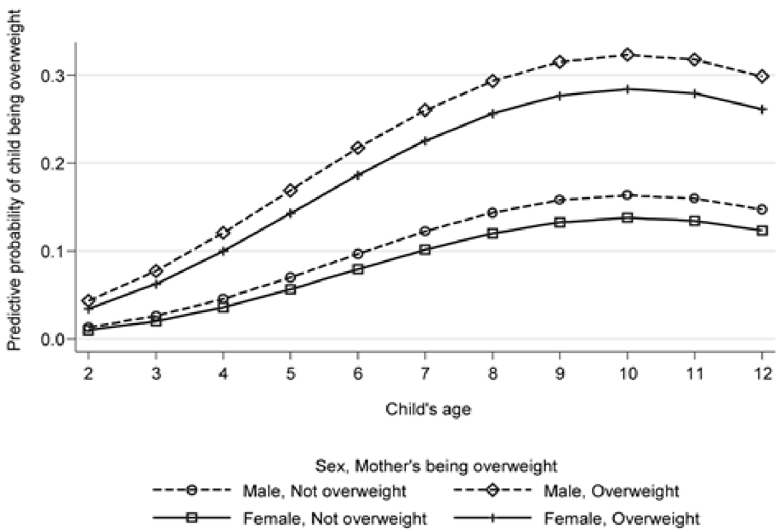


Figure 3 shows the predicted probability of a child being overweight by child's age, sex and mother's weight status. It generally follows the average partial effects estimates, and we find a nonlinear relationship between the child's age and the probability of being overweight. Overall, the child's probability of being overweight is the highest in boys with obese mothers and the lowest for girls with non-overweight mothers. This may imply that policy makers need to have various approaches for each group to alleviate childhood obesity.

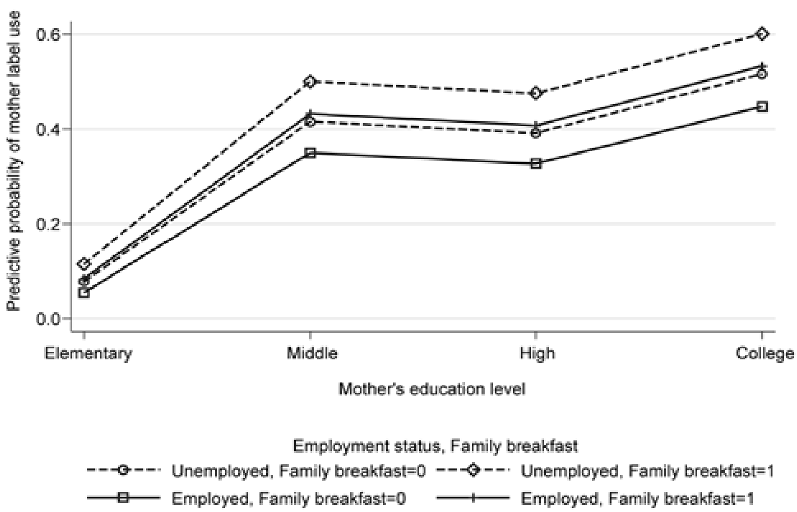
Figure 3. Predicted probability of a child being overweight over the child's age, by the child's sex and mother being overweight



Maximum likelihood estimates of the mother equation (3) are presented in Table 5. The probability of the mother's nutrition label use increases with her education level. This result is consistent with the expectation that mothers who are more educated tend to read nutrition labels. Our results also indicate that the mother who has breakfast with her family has a significant and strong tendency of reading nutrition labels. This supports our belief that a mother having breakfast has a greater concern for health and nutritional balance. Exercise also has a positive correlation with the choice of nutrition label use, as a mother exercising more is likely to have more concern for health. However, a mother who is employed is less likely to read nutrition labels. This might be because employed mothers have less time and inclination for shopping and cooking foods.

In Figure 4, we show the predicted probability of mothers using nutrition labels based on their education level, employment status and ability to have breakfast with family. The dashed lines indicate the status of being unemployed and the solid lines imply employed status. As shown in the estimates of average partial effects, a higher education level increases the probability of the mother's use of labels compared to the base level (elementary school graduates). However, all the other education levels starting from the middle school have similar average partial effects. This also indicates that policy makers and nutrition educators require different approaches for each group to improve the mother's use of nutrition labels.

Figure 4. Predicted probability of mothers using nutrition labels based on education level, by employment status and breakfast with family



The covariance ψ_{21} between the random intercepts of the two equations $(\zeta_j^{(2)}, \zeta_j)$ is estimated using the simultaneous model defined previously in this paper. The model also allows us to test the correlation between 'unobservable factors' in equations. In Table 5, the mother-child covariance ψ_{21} is estimated as −0.113, and the residual correlation between the probabilities of nutrition label use and child being overweight is estimated as −0.067, after conditioning on the observed covariates. The interdependence hypothesis is justified by this significant mother-child correlation; therefore, using a joint model is also reasonable. The negative mother-child correlation indicates that if a mother uses nutrition labels, her child is less likely to become overweight. This result is consistent with the findings of the study by Chang and Nayga (2011) that indicate that mothers' use of nutrition label is related with a low probability of their children being overweight.

Ⅳ. Conclusions

In a large body of literature on alleviating childhood obesity, very little actionable information is available on associations between parental use of nutrition labels and children's rate of being overweight. This analysis aimed to examine the determinants of nutrition label use and to see whether a mother's use of nutrition labels and her children being overweight are related. We found that mothers' propensity to use nutrition labels depend on their exercise intensity, ability to have breakfast with family, education level and employment status. The findings of this paper also indicate that the mother-child correlation is significant and negative, controlling for observed covariates. In other words, if mothers use nutrition labels, their children are less likely to be overweight. This finding implies that mothers' use of nutrition labels may reduce children's likelihood of being overweight. However, this study could not examine the causality between label use by mothers and her children being overweight, due to limitations inherent to our multi-period cross-sectional data, in which the households sampled across years are not necessarily the same. As a result, further research should be conducted to determine how the benefits derived from use of nutrition labels by mothers alleviate obesity for children.

The results of this study have some implications for policy makers in Korea. On the one hand, the utilization of nutrition labels may be promoted through providing education programs on the importance of label use and the role of essential nutrients. Customized programs for working mothers who have difficulty acquiring nutrition information may enhance the utilization of nutrition labels. Furthermore, the Korean government may expand the scope of food products covered by nutritional labeling regulation to benefit child health. It should, however, be noted that use of the labels does not necessarily ensure better nutritional behavior. Therefore, when the objective is to bring down the rate of childhood obesity, further studies are required to determine what specifically reduced obesity when mothers used labels, so that policy makers can develop and implement strategies and programs that will result in better health practices.

REFERENCES

Alviola, P.A., IV, R.M. Nayga, Jr., M.R. Thomsen, D. Danforth, and J. Smartt. 2014. "The Effect of Fast-Food Restaurants on Childhood Obesity: A School Level Analysis." *Economics & Human Biology* 12(0): 110-119.

Anderson, P.M., K.F. Butcher, and P.B. Levine. 2003. "Maternal Employment and Overweight Children." *Journal of Health Economics* 22(3): 477-504.

Auld, M.C. 2011. "Effect of Large-Scale Social Interactions on Body Weight." *Journal of Health Economics* 30(2): 303-316.

Birch, L.L., and K.K. Davison. 2001. "Family Environmental Factors Influencing the Developing Behavioral Controls of Food Intake and Childhood Overweight." *Pediatric Clinics of North America* 48(4): 893-907.

Byun, J.Y. and K.J. Kim. 2012. "Comparison of Body Composition, Blood Lipid Profiles, HOMA, and Physical Fitness According to BMI in Elementary School Boys" *Journal of Physical Growth and Motor Development* 20(2): 67-73.

Cawley, J., and F. Liu. 2012. "Maternal Employment and Childhood Obesity: A Search for Mechanisms in Time Use Data." *Economics & Human Biology* 10(4): 352-364.

Chang, H.H., and R.M. Nayga. 2011. "Mother's Nutritional Label Use and Children's Body Weight." *Food Policy* 36(2): 171-178.

Chen, L.-K., and W.-S. Yang. 2004. "The Relationships of Maternal Attitudes in Child-Raising with Their Behaviors Regarding Children's Health and Investments in Children's Ability." *Journal of Population Studies* 29: 123-146.

Coe, N.B., and G. Zamarro. 2011. "Retirement Effects on Health in Europe." *Journal of Health Economics* 30(1): 77-86.

Danielzik, S., M. Czerwinski-Mast, K. Langnase, B. Dilba, and M.J. Muller. 2004. "Parental Overweight, Socioeconomic Status and High Birth Weight Are the Major Determinants of Overweight and Obesity in 5-7 Y-Old Children: Baseline Data of the Kiel Obesity Prevention Study (Kops)." *Int J Obes Relat Metab Disord* 28(11): 1494-1502.

Davison, K.K., and L.L. Birch. 2002. "Obesigenic Families: Parents' Physical Activity and Dietary Intake Patterns Predict Girls' Risk of Overweight." *International journal of obesity and related metabolic disorders : journal of the International Association for the Study of Obesity* 26(9): 1186-1193.

Deb, P., W.T. Gallo, P. Ayyagari, J.M. Fletcher, and J.L. Sindelar. 2011. "The Effect of Job Loss on Overweight and Drinking." *Journal of Health Economics* 30(2): 317-327.

Drichoutis, A.C., P. Lazaridis, and R.M. Nayga. 2009. "On Consumers' Valuation of Nutrition Information." *Bulletin of Economic Research* 61(3): 223-247.

Drichoutis, A.C., P. Lazaridis, R.M. Nayga, Jr., M. Kapsokefalou, and G. Chryssochoidis. 2008. "A Theoretical and Empirical Investigation of Nutritional Label Use." *European Journal of Health Economics* 9(3): 293-304.

Duffey, K.J., P. Gordon-Larsen, D.R. Jacobs, O.D. Williams, and B.M. Popkin. 2007. "Differential Associations of Fast Food and Restaurant Food Consumption with 3-Y Change in Body Mass Index: The Coronary Artery Risk Development in Young Adults Study." *American Journal of Clinical Nutrition* 85(1): 201-208.

Francavilla, F., G.C. Giannelli, and L. Grilli. 2013. "Mothers' Employment and Their Children's Schooling: A Joint Multilevel Analysis for India." *World Development* 41(0): 183-195.

Gennetian, L.A., H.D. Hill, A.S. London, and L.M. Lopoo. 2010. "Maternal Employment and the Health of Low-Income Young Children." *Journal of Health Economics* 29(3): 353-363.

Graham, D.J., and M.N. Laska. 2012. "Nutrition Label Use Partially Mediates the Relationship between Attitude toward Healthy Eating and Overall Dietary Quality among College Students." *Journal of the Academy of Nutrition and Dietetics* 112(3): 414-418.

Guthrie, J.F., J.J. Fox, L.E. Cleveland, and S. Welsh. 1995. "Who Uses Nutrition Labeling, and What Effects Does Label Use Have on Diet Quality?" *Journal of Nutrition Education* 27(4): 163-172.

Jeon, M.H. and E.J. Gwak. 2011. "The Study on the Body Image Satisfaction Level and the Self-Esteem of the Obese Children Participating in Sport Activities" *Journal of Korean Physical Education Association for Girls* 25(3): 61-70.

Haugaard, L.K., T.A. Ajslev, E. Zimmermann, L. Ängquist, and T.I.A. Sørensen. 2013. "Being an Only or Last-Born Child Increases Later Risk of Obesity." *PLoS ONE* 8(2): e56357.

Hawkes, C. 2010. "Government and Voluntary Policies on Nutrition Labelling: A Global Overview." In J. Albert ed. *Innovations in food labelling*. Oxford Cambridge Philadelphia New Delhi: The Food and Agriculture Organization of the United Nations and Woodhead Publishing Limited, pp. 37-58.

Kageyama, Y., Ishida, A. Yokoyama, S. Aita, Y. (2007) "Consumer interest and concerns about food labels: With special reference to the Tokyo Metropolitan area" *Agricultural Marketing Journal of Japan* 66: 120-127.

Kang, S.Y., H.S. Ryu, and I.S. Cho. 2010. "Factors Influencing the Obesity of Senior Elementary Students." *Korean Journal of Health Education and Promotion* 27(1): 35-48.

Kim, S.K., M.K. Cho, M.S. Choi, and J.H. Kim. 2013. "The Effects of Parenting Attitude on School Adjustment, and Analysis of Moderating Effect of Peer Attachment" *Korean Journal of Play Therapy* 17(1): 1-15.

Kim, J.H., B.K. Moon. 2010. "Obesity Stress, Eating Behavior and Eating Habits of Elementary School Students." *The East Asian Society of Dietary Life* 20(3): 352-362.

Kim, S.Y., R.M. Nayga, Jr., and O. Capps, Jr. 2000. "The Effect of Food Label Use on Nutrient Intakes: An Endogenous Switching Regression Analysis." *Journal of Agricultural and Resource Economics* 25(1): 215-231.

______. 2001. "Food Label Use, Self-Selectivity, and Diet Quality." *Journal of Consumer Affairs* 35(2): 346-363.

Korea Centers for Disease Control and Prevention. 2007. *The Fourth Korea National Health and Nutrition Examination Survey* (KNHANES IV-1).

______. 2008. *The Fourth Korea National Health and Nutrition Examination Survey* (KNHANES IV-2).

______. 2009. *The Fourth Korea National Health and Nutrition Examination Survey* (KNHANES IV-3).

Korea Centers for Disease Control and Prevention, and Korean Pediatric Society. 2007. *Child Growth Standards* 2007.

Lee, K.-A. 1999. "A Comparison of Eating and General Health Practices to the Degree of Health Consciousness in Pusan College Students." *Journal of the Korean Society of Food Science and Nutrition* 28(3): 732-746.

Lee, K.-I., H.-S. Han, and E.-Y. Son. 2007. "*Analysis of Korean Food Consumption Trends.*" Report R560. Korea Rural Economic Institute.

Lee,H.S. and J.S. Park. 2013. "Development of a Web-Based Obesity Management Program for Elementary School Students" *The Journal of Korean Academic Society of Nursing Education* 19(2): 215-227.

Loureiro, M.L., S.T. Yen, and R.M. Nayga. 2012. "The Effects of Nutritional Labels on Obesity." *Agricultural Economics* 43(3): 333-342.

Mancino, L., J. Todd, and B.-H. Lin. 2009. "Separating What We Eat from Where: Measuring the Effect of Food Away from Home on Diet Quality." *Food Policy* 34(6): 557-562.

Mandal, B. 2010. "Use of Food Labels as a Weight Loss Behavior." *Journal of Consumer Affairs* 44(3): 516-527.

Morrissey, T.W., R.E. Dunifon, and A. Kalil. 2011. "Maternal Employment, Work Schedules, and Children's Body Mass Index." *Child Development* 82(1): 66-81.

Nayga, R.M., D. Lipinski, and N. Savur. 1998. "Consumers' Use of Nutritional Labels While Food Shopping and at Home." *Journal of Consumer Affairs* 32(1): 106-120.

Neuhouser, M.L., A.R. Kristal, and R.E. Patterson. 1999. "Use of Food Nutrition Labels Is Associated with Lower Fat Intake." *Journal of the American Dietetic Association* 99(1): 45-53.

Nie, P., and A. Sousa-Poza. 2014. "Maternal Employment and Childhood Obesity in China: Evidence from the China Health and Nutrition Survey." *Applied Economics* 46(20): 2418-2428.

OECD. 2015. "*Obesity and the Economics of Prevention: Fit Not Fat - Korea Key Facts.*" <http://www.oecd.org/korea/obesityandtheeconomicsofpreventionfitnotfat-koreakeyfacts.htm> (accessed March 8, 2015).

Rabe-Hesketh, S., A. Skrondal, and A. Pickles. 2005. "Maximum Likelihood Estimation of Limited and Discrete Dependent Variable Models with Nested Random Effects." *Journal of Econometrics* 128(2): 301-323.

Ruhm, C.J. 2008. "Maternal Employment and Adolescent Development." *Labour Economics* 15(5): 958-983.

Ruhm, C.J. 2012. "Understanding Overeating and Obesity." *Journal of Health Economics* 31(6): 781-796.

Satia, J.A., J.A. Galanko, and M.L. Neuhouser. 2005. "Food Nutrition Label Use Is Associated with Demographic, Behavioral, and Psychosocial Factors and Dietary Intake among African Americans in North Carolina." *Journal of the American Dietetic* Association 105(3): 392-402.

Sekine, M., T. Yamagami, S. Hamanishi, K. Handa, T. Saito, S. Nanri, K. Kawaminami, N. Tokui, K. Yoshida, and S. Kagamimori. 2002. "Parental Obesity, Lifestyle Factors and Obesity in Preschool Children: Results of the Toyama Birth Cohort Study." *Journal of epidemiology / Japan Epidemiological Association* 12(1): 33-39.

Seo, H.Y. and D.Y. Lee. 2014. "A Correlational Study of Obesity Stress, Self-esteem and Adaptation to School Life regarding to the Obesity Index of Upper Elementary School Students" *Journal of the Korean Society of School Health* 28(1): 80-89.

Takahashi, E., K. Yoshida, H. Sugimori, M. Miyakawa, T. Izuno, T. Yamagami, and S. Kagamimori. 1999. "Influence Factors on the Development of Obesity in 3-Year-Old Children Based on the Toyama Study." *Preventive Medicine* 28(3): 293-296.

Teisl, M.F., and A.S. Levy. 1997. "Does Nutrition Labeling Lead to Healthier Eating?" *Journal of Food Distribution Research* 28: 18-27.

Vanhala, M., R. Korpelainen, P. Tapanainen, K. Kaikkonen, H. Kaikkonen, T. Saukkonen, and S. Keinänen-Kiukaanniemi. 2009. "Lifestyle Risk Factors for Obesity in 7-Year-Old Children." *Obesity Research & Clinical Practice* 3(2): 99-107.

Variyam, J.N., and J. Cawley. 2006. "*Nutrition Labels and Obesity*." National Bureau of Economic Research Working Paper No. 11956.

Wang, H., M. Sekine, X. Chen, H. Kanayama, T. Yamagami, and S. Kagamimori. 2007. "Sib-Size, Birth Order and Risk of Overweight in Junior High School Students in Japan: Results of the Toyama Birth Cohort Study." *Preventive Medicine* 44(1): 45-51.

Webbink, D., N.G. Martin, and P.M. Visscher. 2010. "Does Education Reduce the Probability of Being Overweight?" *Journal of Health Economics* 29(1): 29-38.

Wehby, G.L., and C.J. Courtemanche. 2012. "The Heterogeneity of the Cigarette Price Effect on Body Mass Index." *Journal of Health Economics* 31(5): 719-729.

WHO Expert Consultation. 2004. "Appropriate Body-Mass Index for Asian Populations and Its Implications for Policy and Intervention Strategies." *The Lancet* 363(9403): 157-163.

World Health Organization. 2015. "*Obesity and Overweight*." Fact sheet N°311. <http://www.who.int/mediacentre/factsheets/fs311/en/> (accessed March 9, 2015).

Wu, Q., and M. Suzuki. 2006. "Parental Obesity and Overweight Affect the Body-Fat Accumulation in the Offspring: The Possible Effect of a High-Fat Diet through Epigenetic Inheritance." *Obesity Reviews* 7(2): 201-208.

Yeo, J.H., and E.Y. Kim. 2010. "University Students' Health Habits and Relevant Factors." *The Journal of Korean Academic Society of Nursing Education* 16(2): 283-291.
Yoo, H. 2011. "A study on the prevention of childhood obesity - focusing on the physical education at school." *Korean Journal of Sports Science* 21(1): 273-283.
Zhao, Z.X., and R. Kaestner. 2010. "Effects of Urban Sprawl on Obesity." *Journal of Health Economics* 29(6): 779-787.

Date Submitted: Oct. 4, 2016
Period of Review: Oct. 25～Dec. 12, 2016