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Risk Factors for Obesity Among Children Aged 24 to 80 months in Korea: A Decision Tree Analysis

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ABSTRACT

Purpose: The purpose of this study was to examine the multiple intergenerational risk factors of obesity among children aged 24 to 80 months using national cohort data.
Design and methods: This is a retrospective longitudinal cohort study using the Korean National Health Insurance (KNHI) database, and the number of study participants was 1,001,775 families. Social-Economic Status (SES), parental and child-related factors were examined. Descriptive statistics and Chi-squared Automatic Interaction Detection (CHAID) for a decision tree analysis were conducted.
Results: The prevalence of obesity was 6.57%, and that of overweight was 11.31% among the entire study population. The 17 groups with a prevalence of childhood obesity higher than the mean prevalence rate were classified as high-risk groups for childhood obesity; there were 6 groups with a prevalence of childhood obesity twice as high as the mean prevalence rate from this study. The best predictors were as follows: mothers being obese prior to conception, fathers being obese, non- medical aid beneficiaries, and mothers with hypertension during gestation.
Conclusions: The best predictors of children obesity were parental obesity history and SES. Other parental predictors of outcomes were gestational hypertension and diabetes, older pregnancy, drinking during gestation, and depression after delivery. Child-related outcome predictors were noncompliance with exclusive breastfeeding, a sugar-sweetened beverage intake ≥200 ml per day, and irregular breakfast consumption.
Practice implications: These findings could help community health nurses assess high-risk groups for early childhood obesity and develop or provide effective interventions in the early stages of life.

Statement of the problem

Background of the study

Early childhood obesity is a rising health problem worldwide. It is estimated that the prevalence of obesity in children under 5 years has increased from 32 million in 1990, to approximately 41 million in 2005 (World Health Organization, 2016b). Childhood obesity is known for causing not only obesity in adulthood but also serious health problems. It is the predisposing factor for metabolic syndrome, type II diabetes, and cardiovascular diseases (Kim, Lee, & Lim, 2017; World Health Organization, 2016a). In addition, psychological symptoms, such as depression and a sense of inferiority, can arise and social interaction can be compromised, which could all threaten an individual's capability to successfully achieve developmental tasks. (Vander Wal & Mitchell, 2011).

For these reasons, research has been conducted to investigate predictors of childhood obesity, and various risk factors have been identified (Bammann et al., 2014; Flores & Lin, 2013). According to recent studies, early childhood is a critical stage for shaping lifelong, health-related behaviors, and the effects of interventions that are implemented from an early age are known to be promising (Gurnani, Birken, & Hamilton, 2015; Kim et al., 2017). Nevertheless, previous studies have neglected this fact, as their subjects were restricted mostly to newborns or school-aged children (Bjørge, Engeland, Tverdal, & Smith, 2008; Silveira & Horta, 2008).

Childhood obesity should be described by considering the various factors that might have influenced individuals in a simultaneous and complicated pattern (Robinson et al., 2015). However, one of the weaknesses of existing research on prediction of childhood obesity is that they only have focused on establishing a direct causal relationship between a single variable and obesity. Another weakness is that using

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cross-sectional data to investigate the complicated relationships of various factors in childhood obesity may result in a limited understanding. Globally, there has been an interest in studying the relationship between child obesity and parental health behavior, genetic and environmental factors (Andriani, Liao, & Kuo, 2015; Keane, Layte, Harrington, Kearney, & Perry, 2012; Tarrade, Panchenko, Junien, & Gabory, 2015). However, relevant studies on a national level using various variables through two generation are scarce. To overcome the limitations of existing studies, this study sought to identify multiple risk factors of childhood obesity by longitudinally analyzing national-level, intergenerational data.

Study aim

It is imperative to predict childhood obesity from an early age to be able to implement preventive measures and interventions for children with a high risk of obesity. The purpose of this study was to examine the multiple intergenerational risk factors of obesity among children aged 24 to 80 months using national cohort data.

Methods

Design and sample

This is a retrospective longitudinal cohort study using the Korean National Health Insurance (KNHI) database. The database is composed of qualification data, national health checkup data for infants, children and adults, and health insurance claims data. Qualification data contains all of the information of the insured person and their dependents. The National Infants and Children Health Checkup (NICHC) data set targets children aged 4 to 80 months, and their parents' health checkup records were obtained from the National Adult Health Checkup (NAHC) data set. Claims data contains disease codes using the Korean Standard Classification of Diseases (KCD), which is the Korean version of the International Classification of Diseases (ICD). KNHI was able to release data from 2002 to 2013. Since the NICHC started in 2007, their data from 2007 to 2013 was used; all the other data used in this study pertained to the years 2002 to 2013. The variables selected from the four discrete data sets are presented in Table 1.

For this analysis, the four data sets (qualification, NICHC, NAHC, and claims) were merged into a single database by using two common data fields, namely, the health insurance registration number and the personal identification number. The 'familial relation code' in the qualification data was used as a guide to construct the family units for the study participants: a father, a mother, and their offspring.

The final number of study participants was 1,001,775 families. The flowchart for selecting the study participants is presented in Fig. 1. Prior to merging each data record, missing values and outliers were excluded. The exclusion criteria for outliers were established with the mutual consent s 1,573,434. The reason for the exclusion of non-firstborns is that in families with multiple children, additional weights may be put on the results by analyzing the identical parents. With these children (n = 1,573,434), their parents were searched using family relation codes and health insurance registration numbers. Those who do not have the records of having either fathers or mothers were excluded (n = 3848). The number of families consisting of a father, a mother, and a first-born child was 1,569,586.

Meanwhile, the number of participants for NAHC after the exclusion process was 2,150,573. These participants were merged into the family-unit database (n = 1,569,586). During the merging process, families without health checkup data for both parents (n = 26,732) were removed. Also excluded were those who were over 59 years old when giving birth to their first child (n = 12,602). The oldest possible childbearing age in this study was agreed as 59 years old, based on professional discussion and literature review (Parker, Branum, Axelrad, & Cohen, 2013). Those children who did not have health checkup records after the age of 24 months (n = 400,763) were also excluded. In this study, the exposure group was obese children, and the comparison group was normal and underweight children. Therefore, families with overweight children (n = 127,714) were excluded from the analysis. The final number of study participants was 1,001,775 families.

All personally identifiable information was removed from the data sets to ensure the confidentiality of the participants. This study was approved as an exemption by the Institutional Review Board of Seoul National University (IRB No. E1504/002-014).

Table 1
Materials and variables used in this study.

Materials	Variables
Qualification data	Age, gender, medical aid status, familial relation
NAHC data	Health examination: BMI, WC, SBP, DBP, FBS
	Questionnaire: experience of smoking and drinking
NICHC data	Health examination: birthweight, weight, height, BMI
	Questionnaire: Exclusive breastfeeding, Sugar-sweetened beverage intake, Regularity of breakfast intake
Claims data	Bulimia, depression, preterm, congenital deformity in nervous system, Date of delivery

Note. NAHC = National Adult Health Checkup, NICHC = National Infants and Children Health Checkup, BMI = Body Mass Index, WC = Waist Circumference, SBP = Systolic Blood Pressure, DBP = Diastolic Blood Pressure, FBS = Fasting Blood Sugar Level, KCD = Korean standard Classification of Disease and cause of death.

Measures

The measures and criteria of outcome and predictors are shown in Table 2. The outcome measure was presence of obesity in children aged 24 to 80 months. According to the 2007 Korean National Growth Charts published by the Korea Centers for Disease Control and Prevention (KCDC), for children aged ≥24 months, obesity is defined as a BMI-for-age above the 95th percentile, and normal and underweight is defined as a BMI-for-age below the 85th percentile (Moon et al., 2008). The KCDC adopted the criteria of the CDC (Moon et al., 2008) and applied them to Korean children. *Z*-scores facilitate comparisons across ages and sexes, and allow the mean and standard deviation to be calculated for a group of measures, the description of the relative status of children at the distributions extremes (Kuczmarski et al., 2002; Moon et al., 2008). Under normally distributed curves, percentiles are compatible with z-scores. The 95th percentile is equal to a z-score of 1.65, and the 85th percentile is equal to a z-score of 1.04 (Preedy, 2012). In this study, for children aged ≥24 months, normal and underweight was defined as a BMI-for-age z-score below 1.04, and obesity as a BMI-for-age z-score above 1.65.

Potential predictors of childhood obesity categorized into SES, and parental and child-related factors in this study were identified through a literature review and selected from the four separate data sets. The medical-aid beneficiary status of the insured as of December 2013 was used as an index of SES. Parental factors included parental history of obesity and abdominal obesity, older pregnancy (pregnancy ≥ age 35), hypertension, diabetes mellitus (DM), smoking and drinking, and maternal bulimia and depression (Andriani et al., 2015; Zong, Li, & Zhang, 2015). The definitions that this study adopted are as follows: obesity as BMI ≥ 25 kg/m^2 in Asian adults (World Health Organization, 2000); abdominal obesity as waist circumference above 90 cm in Asian men and 80 cm in Asian women (World Health Organization, 2000); older pregnancy as pregnancy ≥ age 35 (Parker et al., 2013); hypertension as a systolic blood pressure above 140 mmHg or a diastolic blood pressure above 90 mmHg in adults (Mendis, 2014); DM as a fasting blood glucose level above 126 mg/dL (Mendis, 2014). For female obesity and abdominal obesity, only the maternal pre-pregnancy weight status was included. For hypertension and DM, fathers or mothers with a history of this in the NAHC were categorized as having hypertension or DM. Smoking and drinking was defined as fathers or mothers who had responded on an NAHC questionnaire that he or she smoked or

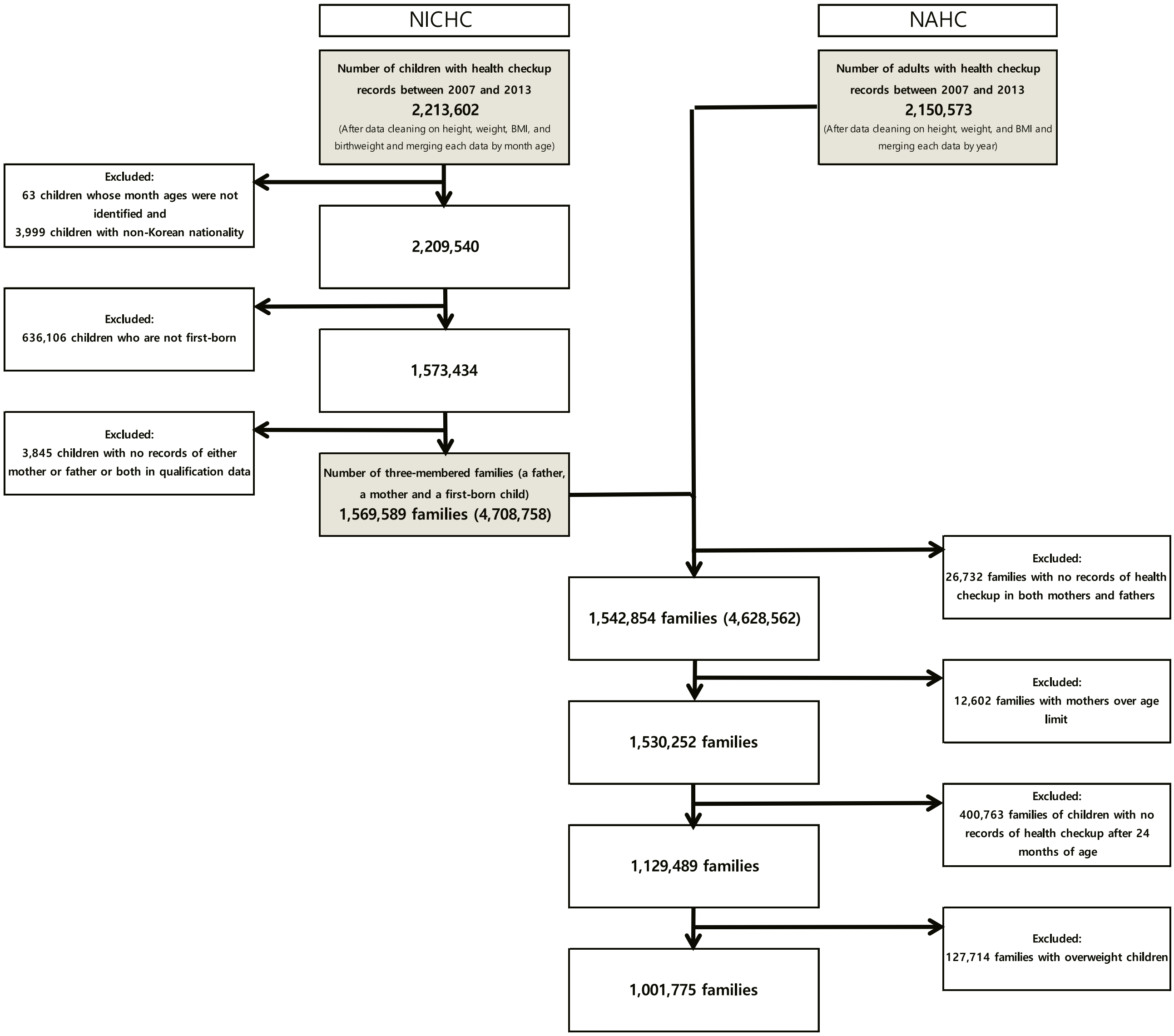

Fig. 1. Flowchart of the process of selecting study participants Note. NICHC = National Infants and Children Health Checkup, NAHC = National Adult Health Checkup.

drank alcohol at least once. Maternal bulimia and depression were defined as mothers who had been diagnosed by medical professionals either for bulimia or depression. For mothers, smoking and drinking, hypertension, DM, and bulimia and depression were further categorized into pre, mid-, and post gestational periods according to either the time period of the experiences or the diagnosed dates.

Child-related factors included preterm, congenital malformation of the nervous system, macrosomia, overweight under 24 months, and nutrition (exclusive breastfeeding, daily intake of 200 ml or more of sugar-sweetened beverages, and regular breakfast). WHO defines preterm as babies who were born at <37 weeks of gestational age (World Health Organization, 2015). The KCD adopted and modified this definition by defining preterm as being born at 28 to 37 weeks of gestational age, a definition followed by this study. Congenital malformation in the nervous system was defined using KCD codes. Macrosomia was defined as infants with a birth weight >2 SD above the mean in studies involving a large population (Maršál et al., 1996). This study adopted this definition by identifying macrosomia as those whose birth weight by gender exceeds z-score 2. According to the 2007 Korean National Growth Charts developed by the KCDC, overweight is defined as a weight-for-height above the 95th percentile in children aged <24 months (Moon et al., 2008). Under normally distributed curves, percentiles are compatible with z-scores (Kuczmarski et al., 2002). In this study, overweight was defined as a weight-for-height z-score above 1.65 for children aged <24 months. The variables related to nutrition for children included exclusive breastfeeding, daily intake of 200 ml or more of sugar-sweetened beverages, and regular breakfast (Blondin, Anzman-Frasca, Djang, & Economos, 2016; Keller & Bucher Della Torre, 2015; Marseglia et al., 2015), all of which were from the NICHC health questionnaire.

Analytic strategy

Descriptive statistical analyses (frequency, percentage, mean, minimum value, maximum value, and standard deviation) were conducted to examine the characteristics of the participants' weight status, SES, parental and child-related factors.

Decision tree analysis is used as a data mining method for establishing classification for developing prediction algorithms for an outcome variable (Witten, Frank, Hall, & Pal, 2016). Recent studies to identify risk factors used either decision trees or logistic regression model. Strengths of decision trees over logistic regression are that it may aid in better decision-making than individual single predictors obtained from a regression model, and it visualizes a given subject's risk (Kang,

Table 2
Measures and criteria of variables.

	Variables		Data set	Measures	Criteria
Outcome	Obesity (24–80 months)		NICHC	Z score for BMI-for-age	≥1.65
Predictors	SES	Medical aid status	Qualification	Beneficiary	
	Maternal factors	History of obesity (pre- gestational period)	NAHC	BMI (kg/m^2)	≥25
		History of abdominal obesity (pre-pregnancy)	NAHC	WC (cm)	≥80
		Old pregnancy	NAHC	Age at delivery (years)	≥35
		Hypertension (pre-,mid,post-gestational period)	NAHC	BP (mmHg)	SBP ≥ 140 or DBP ≥ 90
		Diabetes mellitus (pre-,mid,post-gestational period)	NAHC	FBS (mg/dL)	≥126
		Smoking (pre-,mid,post-gestational period)	NAHC	Health questionnaire	Checked
		Drinking (pre-,mid,post-gestational period)	NAHC	Health questionnaire	Checked
		Bulimia (pre-,mid,post-gestational period)	Claims	KCD	Checked
		Depression (pre-,mid,post-gestational period)	Claims	KCD	Checked
	Paternal factors	History of obesity	NAHC	BMI (kg/m^2)	≥25
		History of abdominal obesity	NAHC	WC (cm)	≥90
		Hypertension	NAHC	BP (mmHg)	SBP ≥ 140 or DBP ≥ 90
		Diabetes mellitus	NAHC	FBS (mg/dL)	≥126
	Child-related factors	Preterm	Claims	KCD	Checked
		Congenital malformation in nervous system	Claims	KCD	Checked
		Macrosomia	NICHC	Z score for weight at birth	≥2.00
		Overweight (0 to 24 months)	NICHC	Z score for weight-for-height	≥1.65
		Exclusive breastfeeding (4–9 months)	NICHC	Health questionnaire	Checked
		Sugar-sweetened beverage intake (18–54 months)	NICHC	Health questionnaire	Checked
		Regular breakfast intake (66–80 months)	NICHC	Health questionnaire	Checked

Note. NICHC = National Infants and Children Health Checkup, NAHC = National Adult Health Checkup, BMI = Body Mass Index, WC = Waist Circumference, BP = Blood Pressure, SBP = Systolic Blood Pressure, DBP = Diastolic Blood Pressure, FBS = Fasting Blood Sugar, KCD = Korean Standard Classification of Diseases.

McHugh, Chittams, & Bowles, 2016). In particular, when the sample size is large, it shows having strong prediction accuracy compared to logistic regression (Witten et al., 2016). For these reasons, a decision tree analysis was used to predict obesity risks in children aged 24 to 80 months, and a Chi-squared Automatic Interaction Detection (CHAID) analysis was also conducted at this time. To guarantee the stability of the model, the database was split into a 60% training set and a 40% validation set. Then, the decision tree analysis was performed on the training set and this model was evaluated using the validation set. In the decision tree analysis, branching stops once there is no risk indicator with a *p*-value <0.10 for division. Values of Root Average Square Error (RASE) and misclassification rates were used to evaluate the stability of the model resulting from the decision tree analysis.

Results

Characteristics of the participants

A total of 1,129,489 participants were examined to figure out the prevalence of obesity in children aged 24 to 80 months (Fig. 1). The numbers of obese, overweight, and normal and underweight children were 74,171 (6.57%), 127,714 (11.31%), 927,604 (82.31%), respectively (Table 3).

In this study, the exposure group was obese children, and the comparison group was normal and underweight children. A total of 1,129,489, overweight children were excluded, leaving 1,001,775 as our final participants. The characteristics of SES, parental and child-related factors are shown in Table 4.

The development of obesity predictive model for children between the ages of 24 and 80 months

The results of the decision tree analysis are shown in Fig. 2. The decision tree model had 18 terminal nodes. The 17 nodes with a prevalence of childhood obesity higher than the mean prevalence rate were classified as groups at high risk for childhood obesity (nodes 1–17); there were 6 nodes with a prevalence of childhood obesity twice as high as the mean prevalence rate from this study (nodes 1, 4, 5, 10, 14, and 15). Compared to the 7.4% prevalence rate of childhood obesity used in this study, the group with the highest risk for childhood obesity showed a predicted prevalence of 32.14% (node 4). The predictors shown in the terminal nodes were as follows: mothers being obese

Table 3
Prevalence of obesity or overweight in children aged 24 to 80 months (N = 1,129,489).

Category	Criteria (Z score for BMI)	n (%)	Mean(SD)	Min	Max
Obesity	≥1.65	74,171 (6.57)			
Overweight	1.0 ≤ <1.65	127,714 (11.31)			
Normal, underweight	<1.04	927,604 (82.13)			
Total			0.05	−5.06	4.56

Note. BMI = Body Mass Index.

Table 4
General characteristics of participants.

Variables	Characteristics	Categories	N	n	%	Mean	SD
SES	Medical aid status	Beneficiary	909,299	5517	0.61		
Maternal factors (before pregnancy)	BMI (kg/m^2)	Normal, underweight (<23)		263,171	80.51		
		Overweight (23 ≤ <25)		36,109	11.05		
		Obesity (≥25)		27,606	8.45		
			326,886			21.04	2.79
	WC (cm)	Abdominal obesity (≥80)		6185	9.15		
			67,586			69.83	7.03
	BP (mmHg)	HTN (SBP ≥ 140or DBP ≥ 90)	326,911	15,367	4.70		
		SBP				115.34	11.38
		DBP				73.35	8.59
	FBS (mg/dL)	DM (FBS ≥ 126)		3667	1.12		
			326,913			90.13	13.45
	Smoking	Yes	303,350	15,426	5.09		
	Alcohol intake	Yes	305,609	192,217	62.9		
	Bulimia	Yes	1,001,509	5805	0.58		
	Depression	Yes	1,001,509	31,487	3.14		
Maternal factors (during pregnancy)	Age at delivery (years)	Old pregnancy (≥35)		143,774	14.36		
			1,001,511			30.33	3.98
	BP (mmHg)	HTN (SBP ≥ 140or DBP ≥ 90)	50,548	551	1.09		
		SBP				109.77	10.91
		DBP				68.37	8.19
	FBS (mg/dL)	DM (FBS ≥ 126)		401	0.79		
			50,477			82.60	12.76
	Smoking	Yes	41,932	332	0.79		
	Alcohol intake	Yes	48,691	7119	14.62		
	Bulimia	Yes	1,001,509	810	0.08		
	Depression	Yes	1,001,509	2641	0.26		
Maternal factors (after pregnancy)	Smoking	Yes	271,037	8922	3.29		
	Alcohol intake	Yes	273,403	103,063	37.7		
	Bulimia	Yes	1,001,509	810	0.08		
	Depression	Yes	1,001,509	61,300	6.12		
Paternal factors	BMI (kg/m^2)	Normal, underweight (<23)		199,600	23.61		
		Overweight (23 ≤ <25)		203,214	24.04		
		Obesity (≥25)		442,553	52.35		
			845,367			25.34	3.35
	WC (cm)	Abdominal obesity (≥90)		261,567	32.88		
			795,474			86.49	7.98
	BP (mmHg)	HTN (SBP ≥ 140or DBP ≥ 90)	845,420	285,970	33.93		
		SBP			74	132.14	12.74
		DBP			52	84.26	9.52
	FBS (mg/dL)	DM (FBS ≥ 126)	845,405	75,041	8.88		
						106.39	26.46
Child-related factors	Z score for weight at birth	Macrosomia (≥2.00)		5096	0.51		
			997,453			−0.45	1.31
	Z score for weight-for-height (0 to 24 months)	Normal, underweight(<1.65)		482,435	91.68		
		Overweight (≥1.65)		43,775	8.32		
			526,210			0.17	0.98
	Sex	Boy	1,001,775	518,487	51.76		
	Preterm	Yes	1,001,775	26,678	2.66		
	Congenital malformation in nervous system	Yes	1,001,775	127,223	12.7		
	Exclusive breastfeeding (4–9 months)	Noncompliance	333,585	182,054	54.57		
	Sugar-sweetened beverage intake (18–54 months)	≥ 200 ml per day	393,799	94,219	11.96		
	Breakfast intake (66–80 months)	Irregular	85,675	7501	4.38		

Note. SES = Socio-Economic Status, BMI = Body Mass Index, WC = Waist Circumference, BP = Blood Pressure, SBP = Systolic Blood Pressure, DBP = Diastolic Blood Pressure, FBS = Fasting Blood Sugar, HTN = Hypertension, DM = Diabetes Mellitus.
Note. Missing data were not included.

prior to conception, fathers being obese, non-beneficiaries of medical aid, and mothers with hypertension during gestation.

SES and parental factors

At the first node in the decision path, maternal obesity was a significant predictor of childhood obesity: the predicted prevalence of childhood obesity was 14.53% with obese mothers, which is much higher than the prevalence of childhood obesity. In addition, as seen in the nodes, paternal obesity was also a significant predictor, with a predicted prevalence of childhood obesity of 17.91%. Medical aid beneficiary status, which was included as a proxy of SES, was the predictor seen in all groups: obese mothers, obese fathers and both parents being obese. Hypertension and DM during gestation, among other maternal predictors, each increased the predicted prevalence of the outcome by twice as much, compared to the group without these predictors. Older pregnancy, drinking during gestation, and depression in the post-gestational period were shown in the model.

Child-related factors

Among child-related predictors, noncompliance with exclusive breastfeeding between 4 and 9 months was the most significant factor for obesity. Additionally, sugar-sweetened beverage intake ≥200 ml per day between 18 and 54 months, and irregular consumption of breakfast between 66 and 80 months were seen in the model.

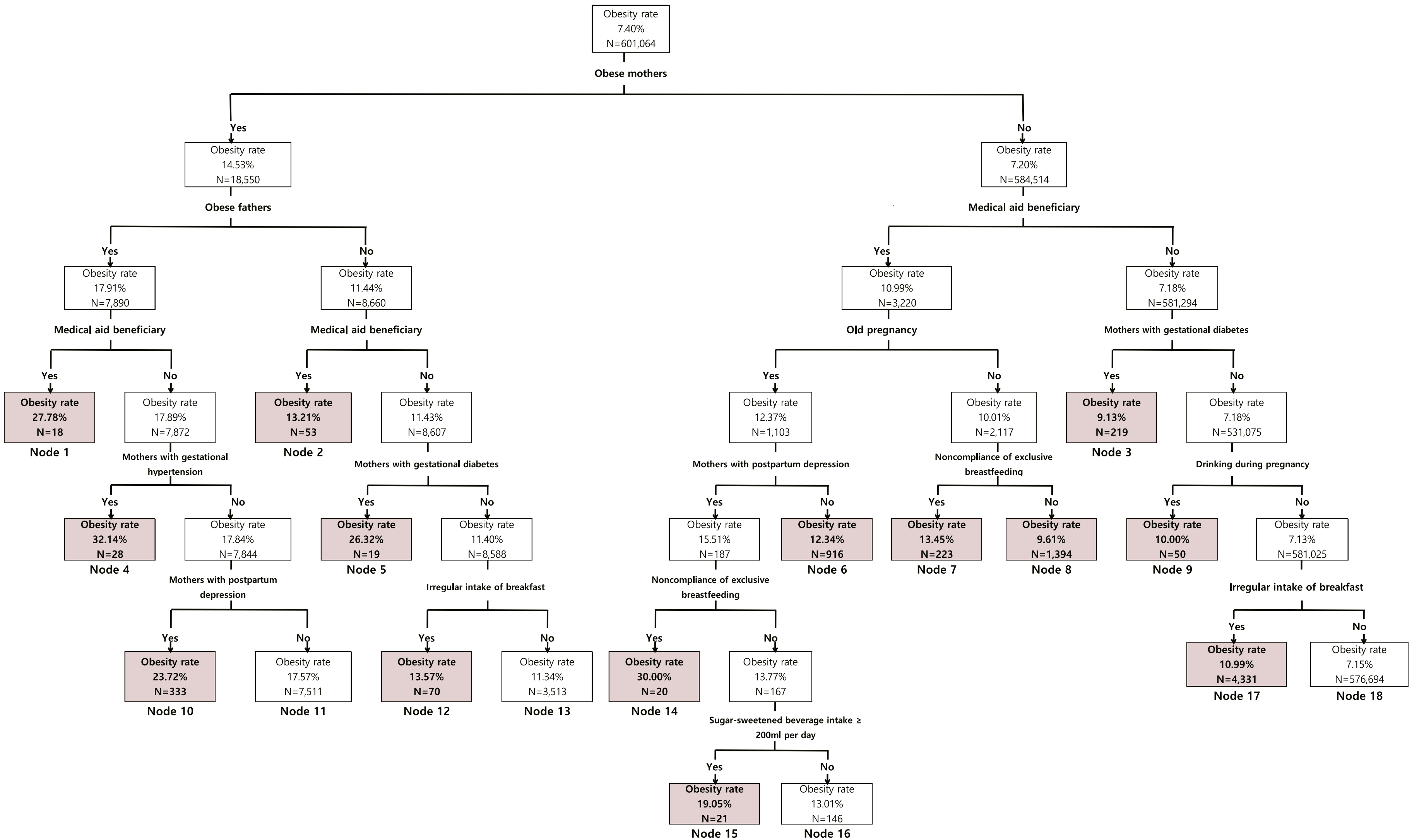

Fig. 2. The decision tree model identifies risk groups with high obesity among children aged 24 to 80 months.

Evaluation of the model

RASE, which indicates the model's power of prediction, and the misclassification rate were 0.26 and 0.07 in the training dataset, and 0.26 and 0.07 in the validation dataset, respectively (Table 5). The overall RASEs and misclassification rates were low, and the difference between the two datasets was minimal. Thus, the predictive model developed in this study can be considered as having a high predictability and stability.

Discussion

This study was conducted to identify SES, parental and child-related factors that predict obesity in children aged 24 to 80 months. Of the predictor variables included, a maternal history of obesity before pregnancy and paternal obesity were the model's best predictors of outcomes. Previous studies also confirmed that parental obesity was the risk factor for obesity in their offspring (Andriani et al., 2015; Zong et al., 2015). The mechanisms by which parental obesity could affect their offspring's excess weight status may be explained by genes and lifestyle. The genetic mechanism involves increased consumption of saturated fats and refined carbohydrates, decreased energy expenditure, and altered lipid metabolism regulation (Williams, Mackenzie, & Gahagan, 2014). In addition, children's health-related behaviors are influenced by the family environment, including parental eating behavior modeling such as snack consumption, high preference for fat and low preference for vegetables (Larsen et al., 2015), and physical habits such as low physical activity and a sedentary lifestyle (Gurnani et al., 2015; Xu, Wen, & Rissel, 2015).

The second-best predictor of outcome was SES, for which 'medical aid beneficiary' was used as proxy. Children's access to healthy food in families with low SES is limited. When left alone by caregivers who, in most cases, are economically active, children are likely to be physically inactive, and exposed to unhealthy food choices and environments, causing nutritional imbalances (Keane et al., 2012; Wang & Lim, 2012).

In this study, it was found that gestational hypertension and DM were important for preventing excess weight gain in offspring. A Chinese study using a national epidemiological survey showed the causal relationship between gestational hypertension and obesity in offspring (Zong et al., 2015). Maternal hypertension could disrupt feto-maternal exchanges, alter fetal tissue development and result in high vulnerability to childhood obesity (Tarrade et al., 2015). Bammann et al. (2014) reported that gestational DM was associated with a 32% excess risk of obesity in offspring (Bammann et al., 2014). In addition, other studies also revealed that the prevalence of overweight children ages 2, 8, and 11 years old was higher in mothers with gestational DM than those without it, because a maternal hyperglycemic condition may genetically cause over nutrition of fetuses (Boerschmann, Pflüger, Henneberger, Ziegler, & Hummel, 2010).

Other parental predictors of outcome included older pregnancy, drinking during gestation, and depression after delivery. The positive correlation between a mother's age and her baby's weight resemble those found in the earlier studies (Parker et al., 2013). Older women are more likely to be exposed to chronic conditions including hypertension and diabetes, and this could indirectly affect the weight of young children (Boerschmann et al., 2010; Flores & Lin, 2013; Parker et al., 2013).

The growth of children when there has been maternal drinking during pregnancy has been discussed in previous studies mainly in terms of underweight or delayed growth (Britto et al., 2017), and the mechanisms explained in the studies were the hormonal changes in the brain (Britto et al., 2017; McConley et al., 2011). However, these studies were inadequate regarding overweight or obesity conditions. In this study, it was found to be associated with childhood obesity. From these results, it could be preliminarily concluded that there may be other potential risk factors explaining the relationship between maternal drinking and childhood obesity. It is necessary to repeat studies to address the deficiencies in the existing research and identify the reasons for the relationship.

Depression in the post gestational period was another outcome predictor. A systematic review study concluded that maternal depression is correlated to obesity in preschoolers (Benton, Skouteris, & Hayden, 2015). Many studies revealed that maternal depressive symptoms resulted in negative parenting practices such as unhealthy feeding behavior, poor health care, and less supervision of TV viewing time (McConley et al., 2011).

Child-related outcome predictors were noncompliance with exclusive breastfeeding, a sugar-sweetened beverage intake ≥200 ml per day, and irregular breakfast consumption. A number of studies reported the preventive effect of breastfeeding regarding childhood obesity (Williams et al., 2014; Zong et al., 2015). One of the reasons for this effect is that mother's milk is produced according to an infant's needs, thus preventing infants from being overfed and promoting optimal feeding (Williams et al., 2014; Zong et al., 2015). Additionally, the risk of obesity increased when children drank sugar-sweetened beverages; existing studies align well with these results (Keller & Bucher Della Torre, 2015). This is explained by the fact that energy gained through liquids is not as complete as that from solid food. Liquids also usually contain a high amount of sugar and a high glycemic index level, which causes blood glucose levels to rise, thereby affecting the sense of hunger and accelerating weight gains (Keller & Bucher Della Torre, 2015; Robinson et al., 2015). In addition, irregular consumption of breakfast was also a predictor of childhood obesity. In this study, satiety from eating breakfast helped decrease snack intake and the size of lunch portions (Ashwell, 2010; Blondin et al., 2016). It is remarkable that the three nutrition variables of the study's child-related factors (exclusive breastfeeding, sugar-sweetened beverage intake, regularity of breakfast consumption) were all shown in the model to be outcome predictors. According to existing study experiments, parental behavior modeling can have an impact on and change their children's eating behavior (Faith et al., 2012; Zong et al., 2015). The diet habits of preschoolers can be modified with parental behavior changes. Family based approaches targeting eating-behavior changes in children are expected to be promising in the prevention of childhood obesity.

Certain variables inserted in the model but that were not possible predictors of obesity. For parental factors, paternal abdominal obesity, hypertension and DM, maternal abdominal obesity in pre-gestational period, smoking in pre, mid- and post-gestational periods, drinking in pre- and post-gestational periods, bulimia in pre, mid- and post-gestational periods, and depression in pre- and mid-gestational periods did not appear as expected factors in the model. And for child-related factors, preterm, congenital malformation in the nervous system, macrosomia, and being overweight under 24 months did not shown in the decision tree. These results should be interpreted cautiously in that, just because the aforementioned variables were not shown in the model, does not mean that these are not relevant variables in explaining childhood obesity. All predictive variables used in the model were selected because they explain childhood obesity per existing literature. As the decision tree paths proceeded, there were some cases in which the number of participants at each terminal node of certain predictive variables was minimal.

There are several limitations to the interpretation of our findings. First, there were a few cases where the secured numbers of the participants in the terminal nodes were insufficient, even though the participants were recruited from a national database. In one case, the

Table 5
Decision tree model evaluation N = 1,001,775.

Categories	Training (60%: 601,046)	Validation (40%: 400,711)
RASE	0.261	0.262
Misclassification rate	0.074	0.074

Note. RASE = Root Average Squared Error.

prediction rate was approximately 30%, but the number of the participants was 20 (node 14), which may lead to a biased estimate. Second, the interpretation of the results would be difficult to extend to other ethnicities since the database used for analysis was specific to South Korea.

This study has its strengths. First, the study is meaningful in that it attempted to identify not just a single causality but also the multifaceted relationships among predictive variables, applying the decision tree analysis method. Childhood obesity was explained with risk factors broken down into intergenerational categories (SES, parental and child-related factors). As a result, the group with a high risk for childhood obesity was identified in Korean children aged 24 to 80 months, and this identification may be a useful decision-making tool for public health nurses. Second, this study attempted to increase the precision of prediction. One of these attempts was through the study participants. This study analyzed all of the NHIS membership, which is representative of the entire Korean population. Another attempt was in the statistical analytic method. The RASE and misclassification rate indicating the model's predictive power were minimized in the analysis. Third, as for the childhood obesity criteria, both Korea-specific and international obesity classification standards were used, which may enable the results to be applied as a reference for international comparison. Fourth, the study merged four separate, population-based data sets into a unified database; this is noteworthy in that a family-based database was established for the first time in Korea. Utilizing the database, intergenerational factors for childhood obesity could be identified. Lastly, most previously conducted studies focused on newborns, schoolers or adolescents as subjects, whereas this study examined early childhood.

Clinical implication

Early identification of children that are at a particularly high risk for obesity is a major challenge. This study identified risk factors of childhood obesity with various intergenerational risk factors in Korea. Community health nurses may utilize obesity prevention or intervention programs that are tailored based on the identified childhood obesity risk factors and by focusing on specific, modifiable factors. In addition, community health professionals can present strategies for early childhood obesity prevention at both the individual and family levels.

Conclusion

A total of 17 groups of predictors of early childhood obesity were identified, which is important in that obesity preventive measures tailored to each group can be presented by utilizing the study results. In this process, this study verified the various variables simultaneously, not just a single variable, and attempted to increase the precision of prediction. The best predictors of early child obesity were parental obesity history and SES. Other parental predictors of outcomes were gestational hypertension and diabetes, older pregnancy, drinking during gestation, and depression after delivery. Child-related outcome predictors were noncompliance with exclusive breastfeeding, a sugar-sweetened beverage intake ≥200 ml per day, and irregular breakfast consumption. This study identified complex and various predictors of childhood obesity, but future studies should be conducted to further examine the still uncertain underlying causalities among various associations of predictors.

CRediT authorship contribution statement

Insook Lee: Supervision, Conceptualization, Methodology, Investigation, Writing - review & editing. **Kyung-Sook Bang:** Investigation, Methodology, Validation, Writing - review & editing. **Hyojeong Moon:** Writing - original draft, Investigation, Data curation, Visualization, Project administration. **Jieun Kim:** Methodology, Writing - original draft, Investigation, Writing - review & editing, Formal analysis, Data curation.

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Conflict of interest

The authors declare no conflicts of interest.

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