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Interaction between exclusive breastfeeding and income on the risk of obesity at age 6 years in the United States

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Abstract

Interaction between exclusive breastfeeding and income on the risk of obesity at age 6 years in the United States

By Enhui Chen

Background: Most studies show that exclusive breastfeeding (EBF) is associated with lower risk for childhood obesity, but some studies show null association. In addition, low income is related to both lower breastfeeding prevalence and higher risk for childhood obesity, but the interaction between breastfeeding history, income, and childhood obesity is unclear. This study examined the interaction between EBF and income on the risk for obesity at age 6 years.

Method: This study analyzed data from the Infant Feeding Practice Study II and its Year 6 Follow Up study (n = 1542). Regression analysis was used to model the prevalence of childhood obesity at age 6 years by EBF duration, categorized as not EBF, EBF < 6 months, and EBF ≥ 6 months. We tested for heterogeneity of the estimates by income status at the beginning of the study, categorized as low income (<185% of federal poverty level) and high income (≥185% of federal poverty level).

Result: In this study, 55.5% of children were not EBF, 37.3% of children were EBF < 6 months and 7.2% of children were EBF ≥ 6months, 12.7% of children were obese (BMI z-score ≥ 1.64) at age 6 years, and 35.2% of households reported income < 185% of federal poverty level at the beginning of the study. There is no association between EBF and risk of obesity at age 6 years, whether the children were EBF < 6 months (aOR = 0.93, 95% CI = 0.64, 1.33) or EBF ≥ 6 months (aOR=0.99, 95% CI = 0.47, 2.07). In addition, heterogeneity test indicated income did not affect the association (p=0.63).

Discussion: There is no association between EBF and childhood obesity at age 6 years. Income at the beginning of the study did not affect the association between EBF and childhood obesity at age 6 years.

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INTRODUCTION

The Healthy People 2020 goals aim to promote health and reduce chronic disease risk through the consumption of healthful diets and achievement and maintenance of healthy body weights. Childhood obesity, defined as a Body Mass Index (BMI) at or above the 95th percentile for children of the same age and sex, is predictive of the development of adult obesity. Childhood obesity is also associated with risk for many chronic conditions and higher healthcare costs due to chronic condition management. Childhood obesity is disproportionally higher among low income population or families with annual household income below 185% of federal poverty level. Most studies show that exclusive breastfeeding (EBF) is associated with lower risk for childhood obesity, but some studies show null association. In addition, families living in low income tend to practice EBF less than the general population. Thus, it is appropriate to examine whether the association between EBF and risk for childhood obesity differs by income status, and the results of this study could influence the implementation of policy to target EBF among low income families to reduce the disparity in childhood obesity. The overall goal of this study is to contribute to the evidence base regarding the association between EBF and childhood obesity, and to examine whether the association differs by income status.

BACKGROUND

Childhood Obesity Prevalence and Consequences

The World Health Organization (WHO) stated that over 42 million children worldwide under the age of five were estimated to be overweight (one standard deviation BMI for age and sex) in 2013. The highest rates of childhood obesity have been observed in developed countries; however, its prevalence is increasing in developing countries as well (1). According to the American Heart Association, 12.7 million (16.9%) children ages 2 to 19 in the United States were obese, and 11.2 million (14.9%) children ages 2 to 19 in the United States were overweight (BMI at or above the 85th percentile and below the 95th percentile for children of the same age and sex) in 2012. In addition, there have been no significant changes in obesity prevalence between 2011-2012 (2), and nearly a fifth of children aged 6 to 19 remained obese, which was more than twice the prevalence just two decades ago (3).

Children who are obese during childhood are at a higher risk for diabetes, cardiovascular diseases, breathing problems, psychological stress, and impaired social, physical, and emotional functioning. In addition, studies show that obese children are more likely to stay obese into adulthood (1) with approximately 70% of obese adolescents becoming obese adults (4). Moreover, the management of obesity places a great financial burden on individuals who suffer from this condition. For instance, the lifetime direct medical cost, defined as costs borne by the healthcare system in addressing the illness, for a 10 years old obese child is estimated to be $19,000 (3). The direct medical costs increase by 2.3% for each BMI unit above 25 and by 1.3% for each additional year in age based on published estimates (3). Being obese during childhood and adolescence results in numerous additional health concerns that cost the United States approximately $147 billion annually (5). The health and financial burdens and the high prevalence associated with childhood obesity make the prevention of this problem an important public health goal.

Causes of Childhood Obesity

It is widely accepted that the rise in obesity may be partially due to the imbalance between energy consumption and expenditure and with energy balance being associated with lifestyle behaviors and dietary intake preferences (1). Previous studies showed that childhood obesity is a multifactorial problem involving prenatal influences (6) (7) (8), fetal and early childhood attributes (9) (10), lifestyle behaviors (5), socio-demographic characteristics (11) (12) (13), and gene-environment interactions (14) that take place from pregnancy through early childhood development. It is therefore challenging to address all the factors that are associated with childhood obesity in one intervention. However, it may be possible to target a specific modifiable risk factor at early developmental stages in an attempt to guide the child on a healthy life trajectory and reduce the risk for later obesity.

Prenatal Influence

A systematic review identified a significant association between maternal obesity and childhood obesity (6), and data from the National Examination Survey III indicated that maternal obesity doubled the risk of being overweight in young children (7). Children whose mothers smoked during pregnancy had higher adiposity levels than children of non-smokers (8). Conversely, another study looking at lower maternal age at having a first child was associated with reduced odds of severe obesity among children in the United States (15). Maternal gestational weight gain may directly program fetal development and child adiposity by insulin distribution, and its indirect effect may be attributable to shared genetics and obesity-related behaviors (9).

Fetal and Early Childhood Attributes

Basal metabolic rate or metabolism accounts for 60% of total energy expenditure, and it has been hypothesized that obese individuals have lower basal metabolic rates, but the differences in basal metabolic rates are not likely to be responsible for the rising rates of obesity (1). Birth

weight, as a proxy of in utero nutrition and growth, is associated with maternal gestational weight gain as well as adiposity in later life (9). A systemic review identified that high infant birth weight and rapid gestational weight gain were associated with children being overweight (10).

Life-style behaviors

Healthy eating choices and food preferences, including fast food consumption (16), sugary beverages intake (17), and increases in snacking and food portions (18), are related to the development of childhood obesity. A review showed an association between weight gains and consumption of fast food, the link between consumption of sugary beverages and increased in BMI, the increase in overall caloric intake due to snacking and the relationship between consumption of large portion and excessive caloric intake (1). In addition to energy imbalance, increase in sedentary lifestyle is associated with decrease in physical activity, which together increases the risk of obesity. Overall, childhood obesity prevalence has been associated with low levels of physical activity, higher rates of sedentary behavior, and suboptimal nutrition (5).

Socio-demographic Characteristics

Socioeconomic status (SES), as measure of family income, influenced the development of childhood obesity, and it is related to food availability, food consumption and physical activity (19). Children who remained in low-income situations throughout childhood were 2.5 times more likely to maintain being overweight compared to children who were never of low-income status, and children who transitioned into low-income situations during childhood were twice as likely to be obese compared to children who were never of low-income status (12). Other than household income, education is other common SES indicator. A systematic review showed that there is generally an inverse association between SES, measured by parental education, and childhood obesity in high-income country (20). In addition, children of low-educated mothers have higher mean BMIs compared to children of higher educated mothers (11).

Gene-environment interaction

Genome-wide association studies (GWASs) showed that some loci previously reported from GAWS analyses of adult BMI and/or obesity may also have similar effects in childhood obesity (4). GWAS analyses have identified approximately 40 loci, and heritability studies estimated that between 60%–80% of the phenotypic variance in BMI can be explained by genetic variation (21). In addition, when several relatives were joined in the same design, the BMI was 25–40% heritable (1). Multiple studies showed that genes and environments act synergistically, whereby the environment interacted with genetic makeup and expression to influence a trait, and that such interaction might be the responsible factor for differences in the development of childhood obesity within and among populations (14).

Exclusive breastfeeding

Breastfeeding Recommendations and Practices in the United States

The WHO recommends EBF up to 6 months of age, with continued breastfeeding along with appropriate complementary foods up to two years of age or beyond. For WHO, EBF meant that the infant only received breast milk and no other liquids or solids. The American Academy of Pediatrics (AAP) also proposed a similar recommendation for EBF. AAP recommends infants should be fed breast milk exclusively for the first 6 months of life, with continued breastfeeding while gradually introducing solid food after the first 6 months and until the infant is one year old. After one year, breastfeeding can be continued if mutually desired by the mother and her infant. For AAP, EBF meant that infant did not receive any additional foods (except vitamin D) or fluids unless medically recommended.

According to the 2014 breastfeeding report card, on a national level, 79.2% of infant were ever breastfed (including infants who were exclusively breastfed, ever breastfed or fed a mixture of formula and breast milk), 49.4% were breastfed at 6 months, and 18.8% were EBF at 6 months. Breastfeeding prevalence differs by maternal race/ethnicity, maternal education, and

income (22). EBF prevalence at 6 months varied by income, mothers with an income of six times above the poverty line were at 21% and those below the poverty line were at 12% (23).

Breastfeeding Practices and Childhood Obesity

Breastfeeding is the most well-known and natural method of infant feeding practice. Studies showed adherence to WHO breastfeeding recommendation is related to the reduction in risk of infectious diseases (24) and the potential protective effect against obesity in later life (25). A meta-analysis found that for children who were ever breastfed in the first year of life, the odds of being overweight decreased by 15% (26). In addition, a cross-sectional study based on data from the 2003 National Survey of Children's Health showed that children who had been breastfed for less than 3 months had 3.1% lower probability of being normal weight ($p = 0.013$) and 4.7% higher probability of being obese ($p = 0.013$) compared to children who had been breastfed for 3 months and above (27). Moreover, a study among grade 5 students in Canada showed that those who were only formula fed were 1.5 times more likely to be obese relative to their peers who were EBF, and those who were combination fed for less than 6 months relative to those EBF were 1.3 times more likely to be overweight (28). Yet, another study conducted in the Netherlands showed that overweight infants had four times higher odds of being overweight in childhood compared with those who were not overweight, irrespective of feeding type (29). The inconsistency is likely due to differences in the study populations, and the Netherlands study population had mothers with high education level and 43% of children were EBF for at least 3 months. Nevertheless, the inconsistency in results on the association between EBF and the risk for childhood obesity is concerning because it can lessen the compliance to the EBF recommendation.

Proposed Study

According to the United States Census, there were 46.7 million people below the federal poverty thresholds resulting in an overall low income rate of 14.8% in the population in 2014.

According to the Centers for Disease and Control Prevention, prevalence of obesity among children aged 2-4 varied by income, children in families with income < 50% of federal poverty level were at 14.2% and those with income > 151-185% of federal poverty level were at 11.8% in 2011. In addition, low income mothers reported that breastfeeding is restrictive and inconvenient to them (30). Previous studied showed inconsistent results about the association between EBF and the risk for childhood obesity. Due the inconsistent findings in previous studies, this study aims to examine the association between EBF and the risk for childhood obesity. In addition, due the disparities in childhood obesity and EBF prevalence among low income families, this study will also examine the interaction between EBF and income on the risk for childhood obesity (Figure 1). Ultimately, the overall goal of this study is to contribute to the evidence base regarding the association between EBF and childhood obesity, and to examine whether the association differs by income status.

METHODS

Study Design and Study Sample

The Infant Feeding Practices Study II (IFPS2) and its Year Six Follow-Up (Y6FU) study were conducted by the Food and Drug Administration in collaboration with the Centers for Disease Control and Prevention. IFPS2 was a longitudinal study focused in two parts: (1) EBF from birth up to one year of age and (2) the diets of women recorded during the third trimester of pregnancy and during the fourth month postpartum. In 2005-2007, the study selected its source sample from a national consumer opinion panel consisting of 500,000 households. 4,902 pregnant women from across the nation participated in the IFPS2. Mothers who qualified for the study were at least 18 years old. Those pregnant women who gave birth to a singleton, full-term, or near-term (≥ 35 weeks gestation), infant weighing ≥ 5lbs at birth were selected. From that sample, those without medical conditions that would affect feeding continued in the IFPS2 study and qualified for the follow up study. IFPS2 used mail questionnaires to collect data from the participants when their children were 3 weeks (neonatal period), 2 months, 3 months, 4 months, 5 months, 6 months, 7 months, 9 months, 10.5 months, and 12 months old. 2,958 of the 4,902 qualified participants continued their participation in the IFPS2 through their child's first year. In 2012, the Y6FU was conducted in a cross-sectional mail survey. Participants of the IFPS2 who have answered at least the prenatal and neonatal IFPS2 questionnaires and were not disqualified afterwards due to medical reasons that affected infant feeding were qualified for the Y6FU. 1,542 of the 2,958 mothers who participated in the IFPS2 were qualified for the follow-up study and yielded a response rate of 52.1%.

The main IFPS2 study examined the foods fed to infants, infant sleeping arrangements, factors contributing to EBF, mothers' intrapartum hospital experiences and postpartum depression, mothers' employment status and child care arrangements and diets of pregnant (≥ 3 trimester) and postpartum (about 4 months postpartum) women. Prenatal and postpartum Diet

History Questionnaires (DQH) collected information from a subsample of mothers about their food consumption and intake of nutrients from foods and dietary supplements.Y6FU accessed information on child's weight and height, child's physical and oral health, child's behavioral and developmental outcomes, child's food allergies, child's dietary practices, child's eating behaviors, child's physical activity level, and child's sleep patterns.

Measures

Exclusive Breastfeeding

The main exposure of this study is EBF. EBF is calculated based on the duration of EBF obtained using the data from the IFPS2 questionnaires. The duration of EBF is estimated as the midpoint of infant age on the last questionnaire in which the mother indicated EBF and infant age on the first questionnaire in which she indicated she was not EBF. The current breastfeeding recommendation is EBF for six months. Thus, EBF duration is categorized as (1) not EBF, (2) EBF < 6 months, and (3) EBF ≥ 6months.

Income Status

This study examines whether the association between EBF and risk for childhood obesity differs by income. The total yearly income of all members in the house before tax was obtained from the demographic questionnaire, and the total yearly income is used to calculate the percent of poverty in relation to the federally identified poverty thresholds. Income status is categorized as low (< 185% of federal poverty level) and high (≥ 185% of federal poverty level). Household income < 185% of federal poverty level is also the income criteria for many federal assistant program, such as the Special Supplemental Nutrition Program for Women, Infants, and Children.

Childhood Obesity

The outcome of this study is obesity at age 6 years. For children and adolescents aged 2-19 in the United States, obesity is defined as BMI at or above the 95th percentile for children of

the same age and sex. In this study, BMI z-score adjusted for age and sex is a useful proxy measure for adiposity (31), and in 8-10 year old children, BMI z-score change is a good proxy for fat mass z-score change (12). Classification of obesity for 5-19 year old is defined as BMI z-score ≥ 1.64, which corresponded to BMI percentile $\geq$ 95th relative to suitable reference population (24).

Covariates

The covariates for this study include several maternal characteristics that are previously shown to be related to both childhood obesity and EBF. All of the maternal characteristics were collected from the demographic questionnaire or the prenatal questionnaire. Mother's weight and height just before pregnancy was used to calculate BMI. Maternal obesity is defined as women whose BMI is greater than or equal to $30 kg/m^2$ (32). Pregnancy smoking status is defined as "currently smok[ing] at least one cigarettes on a daily average" during pregnancy, and dichotomized as "did not smoke any cigarette" or "smoked at least one cigarette on an average day". Similar to previous published studies using the IFPS2 data, maternal age is categorized into four categories: (1) 18-24, (2) 25-29, (3) 30-34, and (4) 35 or above. Maternal education level is defined the highest level of education completed by the mother prior to the study. Similar to previous published studies using the IFPS2 data, maternal education is categorized into three categories: (1) high school graduate or less, (2) some college, and (3) college graduate or more. Maternal race/ethnicity was reported on the demographic questionnaire. Similar to previous published studies using the IFPS2 data, maternal race/ethnicity is categorized into four categories: (1) Non-Hispanic white, (2) non-Hispanic black, (3) Hispanic of all races, and (4) non-Hispanic of all other races.

Statistical Analysis

The IFPS2 dataset and the Y6FU dataset were merged to present the characteristics of the children and mother who participated in both the IFPS2 and Y6FU studies. The two datasets were

merged by participant ID to allow variables from both studies to be matched to a single participant. The merge resulted in a sample size of 1,542 mother-child pairs for final analysis. Among the 1,542 pairs, there were 1,542 pairs with data on income status, 1,542 pairs with data on EBF duration, 1,541 pairs with data on maternal age, 1,538 pairs with data on pregnancy smoking status, 1,523 pairs with data on maternal obesity status, 1,513 pairs with data on maternal race/ethnicity, 1,471 pairs with data on maternal education levels, and 1,408 pairs with data on obesity status at age 6 years. Only complete cases were used in the final analysis with the assumption that the outcome variable was missing at random, and the missing is likely due to failure to return the demographic questionnaire or the values were biologically improbable or impossible. For the merged dataset, 12.7% of the children were obese at age 6 years.

Descriptive analysis was conducted to characterize the study population using χ^2 tests. The distribution of the following characteristics were calculated by EBF duration: maternal age during pregnancy, income status prior to study, maternal race/ethnicity, maternal education prior to study, maternal obesity status just before pregnancy, pregnancy smoking status, and childhood obesity status at age 6 years. Multivariable logistic regression was used to model the prevalence of childhood obesity at age 6 years. The Odds Ratio (OR) and 95% confidence interval (95% CI) were calculated from a multivariable logistic model to show the association between EBF and risk for childhood obesity. Test of heterogeneity was conducted to examine whether the association between EBF and risk for childhood obesity differs by income status. The prevalence ratio (PR) and 95% CI of obesity at age 6 years was calculated by EBF duration, and the probability and 95% CI of developing obesity at age 6 years was calculated by EBF duration. All the analyses will be performed on the merged dataset with SAS 9.4.

RESULTS

The merged dataset included 1,542 mother-child pairs from the IFPS II and its Y6FU studies. Table 1 shows the overall characteristics of the 1,542 mother-child pairs and the same characteristics by EBF duration. Overall, about 90% of the mothers were at least 25 years old when they became pregnant, 86.6% of the mothers were white, 46.2% of the mothers had at least a college degree prior to the study, 35.2% of the mothers had household income < 185% of federal poverty level prior to study, 24.8% of the mothers were obese just before pregnancy, 7.4% of the mothers smoked during pregnancy, and 12.7% of the children were obese at 6 years old. In addition, EBF is associated with maternal age ($p < 0.01$), maternal race/ethnicity ($p = 0.01$), maternal education ($p <0.01$), maternal obesity ($p = 0.01$), and pregnancy smoking status ($p <0.01$). However, EBF is not associated with income status ($p = 0.24$) and childhood obesity ($p = 0.10$).

Table 2 shows the odds of childhood obesity at age 6 years by EBF duration. Test of collinearity was conducted, and maternal race/ethnicity was screened out of the logistic model due to the presence of collinearity. The odds of obesity at age 6 years among children who were EBF < 6 months compared to the odds of obesity among children who were not EBF is 0.93 (95% CI = 0.64, 1.33). The odds of obesity at age 6 years among children who were EBF ≥ 6 months compared to the odds of obesity among children who were not EBF is 0.99 (95% CI = 0.47, 2.07). The adjusted ORs of 0.93 and 0.99 indicate that there is no association between EBF and risk for obesity at age 6 years. In addition, mother's age just before pregnancy is not statistically associated with childhood obesity ($p = 0.50$). But, childhood obesity is associated with maternal age during pregnancy ($p < 0.01$), maternal education prior to the study ($p < 0.01$), and pregnancy smoking status ($p <0.01$). Test for heterogeneity of the estimates by income at the beginning of the study is not significant (p 0.62), therefore stratum specific estimates are not reported.

Table 3 shows the prevalence of obesity at age 6 years by EBF duration. The prevalence of obesity at age 6 years among those who were EBF < 6 months compared to the prevalence of obesity at age 6 years among those who were not EBF is 0.94 (95% CI = 0.67, 1.31). The prevalence of obesity at age 6 years among those who were EBF ≥ 6 months compared to the prevalence of obesity at age 6 years among those who were not EBF is 0.99 (95% CI = 0.49, 1.99). The PRs of 0.94 and 0.99 indicate that there is no association between EBF and prevalence of obesity at age 6 years. In addition, Table 3 also shows the probability of becoming obese at age 6 years by EBF duration. The probability of becoming obese at age 6 years among children who were not EBF is at 0.14 (95% CI = 0.12, 0.17), among children who were EBF < 6 months is at 0.11 (95% CI = 0.06, 0.14) and among children who were EBF ≥ 6 months is at 0.10 (95% CI = 0.05, 0.17). Similar to aORs, and PRs, the association between EBF duration and the probability of becoming obese at age 6 years is not significant (p = 0.10).

DISCUSSION

This study aims to examine the interaction between EBF and low income status on the risk of obesity at age 6 years. Among the 1322 mother-child pairs in final analysis, the aORs, PRs, and the probabilities of obesity at age 6 years show that there is no association between EBF and risk for childhood obesity. This finding is similar to a previous study where the majority of the study population were educated white mothers. There are several factors that might attributed to the non-significant association between EBF and risk for obesity at age 6 years. First, all the children in study are full term infant. A randomized controlled trial (RTC) done in Belarus showed that among term infant, increased duration and exclusivity of breastfeeding did not prevent overweight or obesity (33). Second, 10 children were EBF $\geq$ 6 months, and it might be difficult to detect a small or significant difference in risk of obesity at age 6 years in a small sample. This also implies that the study is under power, and we need to improve the power of the study. Third, previous studies may have showed uncontrolled bias estimates due to confounding (34). A model needs to address more factors that could have confounded the true estimates. In addition, test of heterogeneity indicated that income status did not affect the association between EBF and risk for childhood obesity. This finding might be related to the non-significant association between EBF and income ($p = 0.24$). In addition, only 5 low income children were EBF $\geq$ 6 months, and this makes it hard to detect whether income affects the association between EBF and risk for obesity at age 6 years. Increase the power or the sample size of the study should resolves this issue.

In this study, maternal characteristics, EBF, and children BMI were successfully linked to allow the examination of the proposed associations. The participants in this study were selected from a subgroup of the consumer opinion panel. Using the panel as the sampling frame increased the participation rate, and as a result, 4,902 agreed to participate in the IFPS II study, and about 60% of the participants were qualified for the follow up study. Among the 2,958 mothers who

qualified for the Y6FU study, 52% completed the study, and their results were used in the final analysis. 48% of the data was lost due to follow up, which is a common problem for a longitudinal study. However, since the participants were selected from a panel, it is less likely that the lost follow ups were related to the outcome of the study and more likely due to the length of the study. Selection from a panel will artificially increase the participant rate. However, the participants of the panel may not be representative of the general population, and the study cannot be generalized to other populations across the United States. In addition, the differences in the distribution of the characteristics among the participants of the follow up study compared to the general population may be associated with EBF practices and/or income status. It is difficult to continuously monitor and capture EBF over a period of one year. The longitudinal design considered the issue with data collection, and several questionnaires were sent out during child development at neonatal, month 2, month 3, month 4, month 5, month 6, month 7, month 9, month 10.5, and month 12 to capture continuous EBF practice. Using multiple questionnaires with approximately one month intervals reduce the likelihood of recall bias and also allows for conservatively measuring continuous EBF.

FUTURE DIRECTIONS

One limitation of the study was the lack of external validity or generalizability. In the future, it would be best to select a population that is more representative of the general population. Using a study population that represents the general population would ensure that the findings may be apply across all the populations in the United States rather than the subgroup of a panel. In addition, the sample size for this study was small due to the loss of follow up. Future studies, particularly study that last several years should consider recruiting a large sample during the initial recruitment period. For example, in order to achieve a power of 80% and an OR of 1.5, a RCT with similar distribution of the EBF as this study needs to have at least 1,014 exposed individuals and 1,014 unexposed individuals. Another benefit of RCT is that a study uses a randomized controlled trial design should address issue with confounding. But, randomized EBF might be unethical, thus, future studies with a randomized controlled trail design must address the ethical issue associated with EBF. In conclusion, a potentially study with larger sample and of a RCT design should be able to show a more accurate estimates on the association between EBF and risk for childhood obesity and potentially the effect of income on this association.

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TABLES

Table 1

Demographic of Characteristics of Mothers and Children who Participated in the IFPS2 and Y6FU Studies according to Exclusive Breastfeeding Duration (N = 1542)*

Variable	Total Sample, %	Exclusive Breastfeeding Duration			
		Not Exclusively Breastfed (n = 856), %	Exclusively Breastfed < 6 months (n = 575), %	Exclusively Breastfed ≥ 6 months (n = 111), %	p -value
Maternal Age[a]					<0.01**
18-24	10.8	11.7	11.0	3.6	
25-29	32.5	28.2	38.0	37.8	
30-34	31.9	34.1	29.6	27.0	
35 or above	24.7	26.1	21.4	31.5	
Maternal Race/Ethnicity[b]					0.01**
Non-Hispanic white	86.6	83.8	89.6	93.6	
Non-Hispanic black	3.7	4.9	2.7	0.0	
Hispanic	5.6	6.6	4.4	3.6	
Other	4.1	4.8	3.4	2.7	
Maternal Education[c]					<0.01**
High School or Less	16.6	20.8	12.8	4.6	
Some College	37.3	37.1	38.4	32.4	
College or More	46.2	42.1	48.8	63.0	
Income Status[d]					0.24
Low	35.2	37.0	32.7	34.2	
Maternal Obesity[e]					0.01**
Yes	24.8	26.9	23.5	14.7	
Pregnancy Smoking Status[f]					<0.01**
Yes	7.4	9.4	5.6	1.8	
Childhood Obesity[g]					0.10
Yes	12.7	14.4	10.8	9.9	

* Infant feeding practices study 2 (IFPS2) was conducted from 2005 to 2007, and the follow up study (Y6FU) was conducted 6 years after IFPS2.

** P < 0.05

[a] Maternal age indicated mother's age just before pregnancy. Infant missing data on maternal age or infant feeding practices history is excluded from the regression analysis (n = 1).

[b] Maternal race/ethnicity was reported by the mother on the demographic questionnaire. Infant missing data on maternal race/ethnicity or infant feeding practices history is excluded from the regression analysis (n = 29).

[c] Maternal education level indicated the highest level of education completed by the mother prior to the study. Infant missing data on maternal education or infant feeding practices history is excluded from the regression analysis (n = 71).

[d] Income Status is categorized as low (< 185% of federal poverty level) and high (≥185% of federal poverty level)

[e] Maternal obesity is defined pregnant women with BMI ≥30. Infant missing data on the mother's BMI or infant feeding practices history is excluded from the regression analysis (n=19).

[f] Pregnancy smoking status indicated pregnant women who smoked cigarette during her pregnancy. Infant missing data on smoking history during pregnancy or infant feeding practices history is excluded from the regression analysis (n=138).

[g] Childhood obesity is defined as BMI z-score ≥ 1.64 according to CDC's classification of childhood obesity. Child missing data on his/her BMI or infant feeding practices history is excluded from the regression analysis (n=137)

Table 2

Multivariable Model Predicting Childhood Obesity Status at age 6 years among children of the IFPS2 and Y6FS (N = 1322)*

	aOR	95% CI
Exclusive Breastfeeding Duration		
Not Exclusively Breastfed	Reference	
Exclusively Breastfed < 6 months	0.93	(0.64, 1.33)
Exclusively Breastfed ≥ months	0.99	(0.47, 2.07)
Maternal Age[a]		
18-24	0.75	(0.40, 1.41)
25-29	0.73	(0.47, 1.15)
30-34	0.95	(0.61, 1.47)
35 or above	Reference	
Maternal Education[b]		
High School or Less	1.67	(1.01, 2.57)**
Some College	Reference	
College or More	0.56	(0.37, 0.85)**
Maternal Obesity[c]	2.02	(1.41, 2.88)**
Pregnancy Smoking Status[d]	2.32	(1.38, 3.88)**

Only completed cases were included in the analysis. Complete cases are mother-child pair with no missing data on infant feeding practices, maternal age, maternal education, maternal obesity and pregnancy smoking status. Maternal race/ethnicity was removed from the analysis due to the presence of collinearity.

* Infant feeding practices study 2 (IFPS2) was conducted from 2005 to 2007, and the follow up study (Y6FU) was conducted 6 years after IFPS2.

** $P < 0.05$

[a] Maternal age indicated mother's age during pregnancy.

[b] Maternal education level indicated the highest level of education completed by the mother prior to the study.

[c] Maternal obesity is defined pregnant women with BMI ≥30 just before the study.

[d] Pregnancy smoking status indicated pregnant women who smoked cigarette during her pregnancy.

Table 3

Prevalence Ratios and the probability of being Obese at age 6 according to Exclusive Breastfeeding Duration (N = 1322)

	PR	95% CI	Probability of Obese at age 6 years	95% CI
Not Exclusively Breastfed	Reference		0.14	(0.12, 0.17)
Exclusively Breastfed < 6 months	0.94	(0.67, 1.31)	0.11	(0.08, 0.14)
Exclusively Breastfed 6+ months	0.99	(0.49, 1.99)	0.10	(0.05, 0.17)

Only completed cases were included in the analysis. Complete cases are mother-child pair with no missing data on infant feeding practices, maternal age, maternal education, maternal obesity and pregnancy smoking status. Maternal race/ethnicity was removed from the analysis due to the presence of collinearity.

FIGURES AND LEGENDS

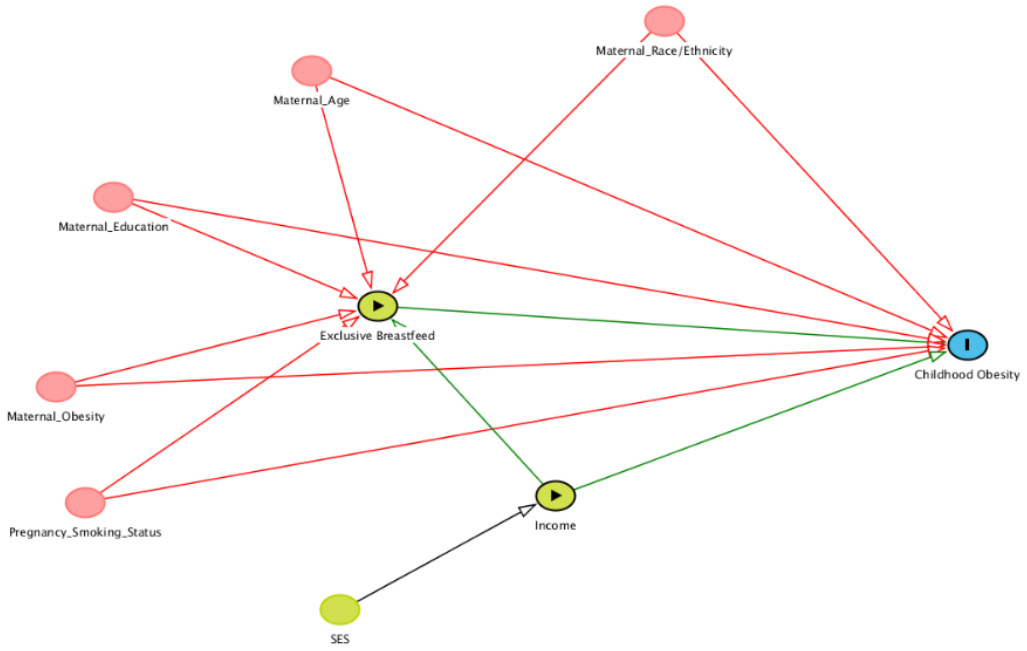

Figure 1. Direct Acyclic Graph (DAG) of the variables of interest in this study

The main exposure of this study is EBF, categorized as not EBF, EBF < 6 months, and EBF ≥ 6 months. The outcome of the study is the development of childhood obesity at age 6 years, defined as BMI z-score ≥ 1.64. The secondary exposure of this study is income status, categorized as low (< 185% federal poverty level) and high (≥ 185% federal poverty level), and it is a proxy measurement for socioeconomic status (SES). Covariates of this study are maternal age during pregnancy, maternal race/ethnicity, maternal education prior to the study, maternal obesity status just before pregnancy, and pregnancy smoking status. This study did not address all the factors that are related to the main exposure and outcome, such as child's birth weight. Green lines suggest possible causal path, whereas red lines suggest biased paths.

This DAG was created using DAGitty published by Johannes Textor, Juliane Hardt, Sven Knüppel in 2011