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Mid-childhood fruit and vegetable consumption: The roles of early liking, early consumption, and maternal consumption

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Abstract

Previous studies have shown that early liking, early consumption, and maternal consumption of fruits and vegetables (F&V) each predict children's F&V consumption, but no one has examined the independent contributions of these three correlated factors. We aim to examine the extent to which each of these 3 factors is associated with F&V consumption in mid-childhood after accounting for the other 2 in the analysis. We analyzed data from 901 mother-child dyads from Project Viva, a prospective pre-birth cohort study. Mothers reported their child's early liking and consumption of F&V at age 2 years and later consumption at mid-childhood (median age 7.7 years). They also reported their own consumption of F&V at 6 months postpartum. We used multivariable linear regression models to examine the independent associations of these 3 factors with mid-childhood consumption, adjusting for socio-demographic, pregnancy, and child confounders. At 2 years, 53% of the mothers strongly agreed that their child liked fruit and 25% strongly agreed that their child liked vegetables. F&V consumption was 2.5 (1.3) and 1.8 (1.1) times/d at age 2 y and 1.5 (1.1) and 1.3 (0.8) times/d in mid-childhood. Maternal F&V consumption was 1.4 (1.1) and 1.5 (1.0) times/d, respectively. Children's early consumption played the most predominant role. For every 1 time/d increment in children's early consumption of F&V, mid-childhood consumption was higher by 0.25 (95% confidence interval [CI]: 0.19, 0.30) times/d for fruits and 0.21 (95% CI: 0.16, 0.26) times/d for vegetables, adjusted for confounders plus the other 2 exposures. In conclusion, children's early F&V consumption has the most significant influence on children's later consumption.

Keywords

Fruit and vegetable consumption; early liking; early consumption; maternal consumption

INTRODUCTION

Eating fruits and vegetables (F&V) is part of an overall healthful diet, and is recommended by the Dietary Guidelines for Americans. Despite the national guidelines, the consumption of F&V is well below the recommended amount in all age groups in the United States, including pre-pubertal school-age children (Go et al., 2013). The first few years of life are a critical period for forming lifelong eating habits and taste preferences (Briefel, Reidy, Karwe, & Devaney, 2004). Long-term habits of eating F&V may start to develop as early as infancy.

Human beings innately prefer sweeter tastes and reject those that are sour and bitter (Birch, 1999). Many non-sweet vegetables have a bitter and/or sour taste, and thus are disliked by many children. There is growing research on how to promote consumption of F&V in early childhood. Early liking and acceptance of flavors are important in determining one's later consumption (Birch, 1999). Based on the culture, familial beliefs, and practices surrounding food and eating, young children learn from their environment what, when, and how much to eat (Savage, Fisher, & Birch, 2007; Schwartz, Scholtens, Lalanne, Weenen, & Nicklaus, 2011). Previous research demonstrated that one of the best predictors of how much F&V children will eat is how much they like the taste of them (Resnicow et al., 1997). Besides environmental influences and cultural practices, genetics also play a role in determining one's taste preferences, as shown in a recent twin study that genetic influences may explain our preferences and liking of vegetables, fruit, and protein (Fildes et al., 2014).

In addition, some studies show that young children's preferences and consumption patterns are largely the result of the food to which they have become familiar and accustomed, and thus early consumption predicts consumption later in life (L. Cooke, 2007). For example, in a small study of mother/child dyads ($n = 60$), the authors found that frequency of F&V consumption of 1-year-old children was significantly associated with F&V consumption when they turned 2 years of age (Gregory, Paxton, & Brozovic, 2011). Using a large longitudinal cohort of US children ($n = 1078$), Grimm and colleagues showed that infrequent consumption of F&V during infancy was associated with low consumption at 6 years of age (Grimm, Kim, Yaroch, & Scanlon, 2014).

Furthermore, parents not only create food environments for children's early experience, but they also influence their children's eating by modeling their own eating behaviors, taste preferences, and food choices. Prior research demonstrated that parental consumption of F&V is a strong predictor of F&V consumption of their children. For example, Hart et al. (2010) showed that fruit ($r = 0.54$, $p < 0.001$) and vegetable ($r = 0.42$, $p < 0.001$) consumption of infants and toddlers were significantly predicted by their mothers' intake. This association has also been observed in 2–6 year-old-children (L. J. Cooke et al., 2004; Fisher, Mitchell, Smiciklas-Wright, & Birch, 2002).

Despite the finding of F&V consumption during early childhood predicting later consumption, Grimm and colleagues' study was not able to tease out the influence of children's taste preferences or environment, such as parental F&V consumption, on this association. These 3 factors – early liking (preference), early consumption, and maternal consumption of F&V – have been studied individually in previous research to predict children's F&V consumption later in life. These 3 factors, however, are often correlated with each other, and the independent contribution of each of these factors remains unclear. Determining the independent contributions is important because it provides insight into designing more effective strategies to help young children develop sustainable healthy eating habits. Therefore, the objective of our study is to examine the extent to which each of these 3 factors is associated with F&V consumption in mid- childhood after accounting for the other 2 in the analysis.

MATERIAL AND METHODS

Subjects

Study participants were from Project Viva, a longitudinal pre-birth cohort of mother-offspring pairs enrolled between April 1999 and July 2002 from Atrius Harvard Vanguard Medical Associates, a multi-site group medical practice in eastern Massachusetts. All mothers in the study signed informed consents, and the study protocols were approved by the institutional review board of Harvard Pilgrim Health Care. Details on recruitment and data collection have been published elsewhere (Oken et al., 2015). Exclusion criteria included non-singleton pregnancy, planning to relocate before delivery, unable to answer questions in English, and gestational age >22 completed weeks at initial prenatal visit. Mothers and children attended in-person visits at 6 months after delivery and in mid-childhood (median 7.7 years). At 2 years after delivery, mothers completed mailed questionnaires updating their child's feeding practices, including liking and consumption of F&V.

Briefly, among 2,128 women with live births, 1,167 had child F&V intake data at mid-childhood, among whom 901 also had data on maternal F&V intake data at 6 months and infant feeding practices at 2 years. Compared with the excluded sample, the 901 women in our analytic sample were slightly older [mean, 32.7 vs. 31.2 y] and leaner [mean BMI, 24.3 vs. 25.3 kg/m²]. Mothers in our analytic sample also showed a higher proportion of identifying as racially white (76.6 vs. 59.0%), were more educated (76.6 vs. 55.7 % college graduates) and had lower rates of smoking during pregnancy (7.7 vs. 16.3%).

Measurements

Main Exposures – Child's liking and consumption of F&V at age 2 y and maternal consumption of F&V (6 months postpartum)—We measured children's liking of F&V at 2 years after birth by 2 questions on a mailed questionnaire: "Does your child like vegetables?" and "Does your child like fruits?" Mothers responded to the questions using 4-point Likert-type scales ranging from strongly agree to strongly disagree. We used responses to these questions as ordinal variables in the data analysis: strongly disagree (score = 1), disagree (score = 2), agree (score = 3), strongly agree (score = 4).

We measured children's usual (in the past month) frequency consumption of F&V at 2 years by a validated semi-quantitative food frequency questionnaire that included 93 items (Blum et al., 1999). The fruit items included oranges or grapefruit, bananas, apples or apple sauce, grapes, peaches or plums, strawberries or other berries, cantaloupe, watermelon, pears, and raisins or prunes. The vegetable items included corn, peas, tomatoes, peppers, carrots, broccoli, green beans, spinach, squash, sweet potatoes or yams, cabbage, coleslaw or cauliflower, and lettuce salad. Response categories included: "Never", "Less than once per week", "Once per week", "2 – 4 times per week", "Nearly daily or daily", and "2 or more times per day".

We also collected maternal dietary consumption at 6 months postpartum, using a brief dietary questionnaire called PrimeScreen, which has been validated against a full-length food frequency questionnaire and plasma biomarkers (Rifas-Shiman et al., 2001). The women were asked how often, on average, they consumed citrus fruits (for example, orange juice or grapefruit juice, oranges, grapefruit), other fruits (for example, apples or pears, bananas, berries, grapes, melons), dark green leafy vegetables (for example, spinach, romaine lettuce, kale, turnip greens, bok choy), broccoli, cauliflower, cabbage, brussels sprouts, carrots and other vegetables (for example, peas, corn, green beans, tomatoes, squash). Response categories included: "Never", "Less than once per week", "Once per week", "2 – 4 times per week", "Nearly daily or daily", and "2 or more times per day". We assumed that the dietary patterns of mothers did not change much over time, and 6 months postpartum F&V consumption is an approximate measure of consumption when their children were age 2 y (Olson, 2005).

Outcome Measures – Mid-childhood F&V consumption—Our main outcomes were F&V consumption (times/d) during mid-childhood (median age 7.7 y), which we collected using PrimeScreen questionnaire (Oken et al., 2015). To assess F&V consumption, mothers indicated the frequency with which their children ate each F&V over the past month, and were given the response options of: "Never", "Less than once per week", "Once per week", "2 – 4 times per week", "Nearly daily or daily", and "2 or more times per day". The fruit items included citrus fruits (e.g., orange juice or grapefruit juice, oranges, grapefruit) and other fruits (e.g., fresh apples or pears, bananas, berries, grapes, melons). The vegetable items included dark green leafy vegetables (e.g., spinach, romaine lettuce, greens/kale), broccoli, cauliflower, cabbage, brussels sprouts, carrots, and other vegetables (e.g., peas, corn, green beans, tomatoes, squash).

Covariates - Confounders—We collected socio-demographic data using questionnaires and interviews. In early pregnancy, mothers self-reported height and pre-pregnancy weight and we calculated pre-pregnancy BMI as weight in kg divided by height in meters squared. We considered the following variables as potential confounders: maternal age at enrollment, pre-pregnancy BMI, race/ethnicity, education, parity, pregnancy smoking status, and child age at outcome, sex, and breastfeeding duration at one year.

Data analysis

We examined distributions of characteristics among included versus excluded participants. We used multivariable linear regression models to examine the independent associations of children's early liking, early consumption, and maternal consumption with mid-childhood consumption of F&V, adjusting for socio-demographic, pregnancy, and child confounders. We adjusted all models for maternal age at enrollment, pre-pregnancy BMI, race/ethnicity, education, parity, pregnancy smoking status, and child age at outcome, sex, and breastfeeding duration at one year. We first ran models with 1 exposure at a time, then with 2 exposures and 3 exposures in the same model. We calculated R-squared (R^2) for each model to estimate the total explained variance in mid-childhood consumption of F&V. We assessed linearity of children's liking by including it as a 4-category variable, and the results demonstrated linear associations; therefore we included the exposures as continuous times/d. We performed statistical analyses using SAS version 9.3 (Cary, NC).

RESULTS

Table 1 shows the characteristics of mother-child dyads in our analytic sample. Mothers were predominantly white (76.6%), had at least a college degree (76.6%), and never smoked (71.6%). Mean (standard deviation [SD]) maternal age was 32.7 (4.7) y, and pre-pregnancy BMI was 24.3 (4.9) kg/m². Mean (SD) children's fruit consumption was 2.5 (1.3) times/d at age 2 y and 1.5 (1.1) times/d in mid-childhood; maternal fruit consumption was 1.4 (1.1) times/d. Children's vegetable consumption was 1.8 (1.1) times/d at age 2 y and 1.3 (0.8) times/d in mid-childhood; while maternal vegetable consumption was 1.5 (1.0) times/d (Table 2). At age 2 y, 53.3% of the mothers strongly agreed that their child liked fruit and 24.6% strongly agreed that their child liked vegetables (Table 2).

Table 3 shows the Pearson correlation coefficients of children's early liking, early consumption, maternal consumption, and children's mid-childhood consumption of F&V. Children's early consumption of F&V was highly correlated with consumption at mid-childhood (fruit: $r = 0.39$, $p < .05$; vegetable: $r = 0.40$, $p < .05$). We also observed high correlations between early liking of F&V and early consumption in our sample (fruit: $r = 0.39$, $p < .05$; vegetable: $r = 0.50$, $p < .05$). Table 4 shows the associations of children's early liking, early consumption, and maternal consumption of F&V with children's mid-childhood consumption of F&V in 7 different models. For fruit consumption, all 3 exposures predicted children's mid-childhood consumption (R^2 for children's early liking 7.9%, early consumption 17.0% and maternal consumption 8.7%). For every times/d increment in children's early consumption of fruits, mid-childhood fruit consumption was higher by 0.30 (95% confidence interval [CI]: 0.25, 0.35) times/d (Model 2). The estimate was slightly attenuated to 0.25 times/d (95% CI: 0.19, 0.30) when we accounted for children's early liking and maternal consumption of fruits in Model 7. As mentioned above, children's early consumption of fruits contributed 17.0% of the explained variance in predicting mid-childhood consumption, and this variance increased slightly to 19.1% after children's early liking and maternal consumption were added to the model.

Similarly, for mid-childhood vegetable consumption, all 3 exposures predicted children's mid-childhood consumption (R^2 children's early liking 10.4%, early consumption 18.2%,

and maternal consumption 10.2%). For every times/d increment in children's early consumption of vegetables, mid-childhood vegetable consumption was higher by 0.29 (95% CI: 0.24, 0.33) times/d (Model 2). The estimate was slightly attenuated to 0.21 times/d (95% CI: 0.16, 0.26) when children's early liking and maternal consumption of vegetables were accounted for in Model 7. Individually, children's early consumption of vegetables contributed 18.2% of the explained variance in predicting mid-childhood consumption, and this variance increased slightly to 22.6% after children's early liking and maternal consumption were added to the model.

DISCUSSION

In a prospective U.S. pre-birth cohort, we examined the associations of children's early liking, early consumption, and maternal consumption with mid-childhood (median age 7.7 years) consumption of F&V. While children's early liking and maternal consumption of F&V were associated with mid-childhood F&V consumption; children's early consumption appeared to play the most dominant role. The contribution of children's early liking was largely absorbed by children's early consumption when these two highly-correlated variables were presented simultaneously in models to predict mid-childhood consumption.

Our findings add to the evidence on the importance of children's early F&V consumption to predict consumption later in life. Thus far, few studies have examined the association of F&V consumption during early life and later consumption. In a longitudinal study limited to $n=60$ children and with only 1 y follow-up, Gregory and colleagues (2011) showed that child frequency of F&V consumption at 1 y predicted the frequency consumption of fruits ($R^2 = 0.22$, $p < 0.001$) and vegetables ($R^2 = 0.29$, $p < 0.001$) at 2 y. A more recent study ($n = 1078$), Infant Feeding Practices Study II, showed that low consumption of F&V (0 to < 1 times/d) during late infancy was associated with infrequent (< once daily) of fruit (adjusted odds ratio: 2.48) and vegetable consumption (adjusted odds ratio: 2.40) at 6 y of age (Grimm et al., 2014). However, both of these studies were limited by not accounting for the influence of children's early liking and maternal consumption of F&V in the analysis, as we have observed in the current study that the association between children's early consumption and later consumption are attenuated after adjusting for these 2 factors.

Food liking is modifiable in early childhood, despite the influence of genetics (Fildes et al., 2014). Several studies have demonstrated that children's preference for and acceptance of new foods are enhanced with repeated exposure to those foods in a non-coercive setting (Birch & Marlin, 1982; Forestell & Mennella, 2007; Maier, Chabanet, Schaal, Issanchou, & Leathwood, 2007; Sullivan & Birch, 1990). Among young children, a minimum of 8–10 exposures are likely needed to observe increases in food acceptance (Birch & Marlin, 1982). We acknowledge that there might be other factors contributing to the relationship of early consumption with later consumption beyond early liking. Some factors we can argue for are: 1) Habits start to form early in life, so even if the child didn't like F&V at an early age he/she might still consume them later in life if he/she has been consuming those F&V since young; 2) Parents might use rewards (e.g., playing with toys, getting a piece of candy, getting to watch their favorite show) as a way to encourage their children to eat F&V even though they don't like them; 3) Children might have the knowledge that F&V are beneficial

for their health and growth via the nutritional education they have received from parents and/or media; therefore, they would consume F&V even though they don't like the taste. Nevertheless, by emphasizing the importance of early consumption of F&V, our study provides insight into designing more effective family-based interventions to help young children develop sustainable healthy eating habits. Strategies to increase consumption of F&V early in life could include introducing F&V to children starting at a young age, perhaps during infancy, and reinforcing F&V consumption during early childhood.

Both observational and experimental studies previously demonstrated that exposures to F&V through breast milk or during complementary feeding periods throughout infancy increased F&V consumption in young children (Birch, Gunder, Grimm-Thomas, & Laing, 1998; Mennella, Jagnow, & Beauchamp, 2001). Furthermore, parents also serve as role models for their children during early childhood. Modeling eating behaviors can help to establish food preference and acceptance in children (Birch, McPhee, Shoba, Pirok, & Steinberg, 1987). However, the many cross-sectional studies of mother-child resemblances in F&V consumption (L. J. Cooke et al., 2004; Fisher et al., 2002; Gibson, Wardle, & Watts, 1998; Papas, Hurley, Quigg, Oberlander, & Black, 2009) cannot assess temporality. Arguably, mother-child feeding relationships are often bi-directional (Kral & Rauh, 2010). While mothers' own consumption can influence their children's eating behaviors and food choices, it is also plausible that children's innate taste preferences influence what mothers are consuming. Thus, children may ask for certain foods, which mothers then consequently make available at home. In other words, children's diet potentially affects maternal diet. As a result, despite the a predominate role of children's early consumption on later consumption demonstrated in our study, one should not discount the contribution of children's early liking and mothers' own F&V consumption on children's later consumption.

Strengths of our study included a relatively large sample size; adjustment for a large number of potential confounders collected prospectively; multivariable regression models to isolate the individual contribution of three highly correlated factors (early liking, early consumption, and maternal consumption); validated questions to measure exposures and outcomes. In this study we measured maternal F&V consumption at 6 months postpartum. It is possible that maternal diet could change considerably over 2 years, however, this measurement could be the strength of the study as it is a critical period for our analysis of examining early life exposures on later life consumption.

We acknowledge that our study has several limitations. First, we assumed that maternal F&V consumption at 6 months postpartum is an approximate measure of consumption at 2-years postpartum. It is possible that mothers can have a drastic change in dietary pattern between this time period; however, research suggests relatively stable food choice behaviors, including F&V consumption, during this postpartum period (6 months to 2 years) (Olson, 2005). We used maternal reports of children's liking and consumption of F&V, which were subjected to misclassification as parents have a tendency to overestimate their child's preferences and consumption of F&V (Burrows et al., 2013; Vereecken, Vandervorst, Nicklas, Covents, & Maes, 2010). Given that Project Viva represents a non-low-income population in eastern Massachusetts, our results might not be generalizable to other populations. Additionally, there is a possibility for selection bias in our data set since women

included in our analytic sample were older, leaner, and had a higher social economic status compared with the excluded sample. Therefore, our results should be interpreted with caution. Lastly, two different types of questionnaires were employed in this study to collect F&V consumption at early and mid-childhood. As a result, we can't statistically claim that F&V consumption during mid-childhood significantly declines from early childhood, and the association between early and later consumption might be underestimated.

CONCLUSIONS

In conclusion, children's early liking, early consumption, and maternal consumption of F&V were associated with mid-childhood F&V consumption. Children's early F&V consumption has the most significant influence on children's later consumption.

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Abbreviations

F&V	Fruit and vegetable
R²	R-squared
CFQ	child feeding questionnaire
Times/d	times per day

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Table 1

Characteristics of Project Viva mothers and children

	Included sample N = 901	
	N	Mean (SD) or N (%)
Maternal characteristics		
Maternal age during enrollment, years	901	32.7 (4.7)
Pre-pregnancy BMI, kg/m ²	898	24.3 (4.9)
Race/ethnicity, %	900	
White		689 (76.6)
Black		84 (9.3)
Hispanic		44 (4.9)
Asian		52 (5.8)
Other		31 (3.4)
College graduate, %	900	689 (76.6)
Nulliparous at enrollment, %	901	438 (48.6)
Smoking status	898	
Never		643 (71.6)
Former		186 (20.7)
During pregnancy		69 (7.7)
Child characteristics		
Mid-childhood age, years	901	7.8 (0.7)
Female, %	901	457 (50.7)
Breastfeeding duration, months	901	6.7 (4.5)

* Variables may add up to less than N = 901 due to missing values

Table 2

Distribution of child's early liking, early consumption, mid-childhood consumption and maternal consumption of fruits and vegetables. Data from 901 mother-child dyads in Project Viva. *

	Mean (SD) or N (%)
Fruits	
Liking at 2 years, %	
Strongly disagree	16 (1.8%)
Disagree	29 (3.2%)
Agree	375 (41.7%)
Strongly agree	480 (53.3%)
Maternal consumption, times/d ϕ	1.4 (1.1)
Consumption at 2 years, times/d	2.5 (1.3)
Consumption at mid-childhood, times/d	1.5 (1.1)
Vegetables	
Liking at 2 years, %	
Strongly disagree	43 (4.8)
Disagree	161 (17.9)
Agree	474 (52.7)
Strongly agree	221 (24.6)
Maternal consumption, times/d ϕ	1.5 (1.0)
Consumption at 2 years, times/d	1.8 (1.1)
Consumption at mid-childhood, times/d	1.3 (0.8)

* Variables may add up to less than N = 901 due to missing values

ϕ Maternal consumption was collected at 6-month post-partum

Table 3
Pearson Correlation of Child's early liking, early consumption and maternal consumption with mid-childhood fruits and vegetables consumption

	Fruits				Vegetables			
	Liking 2 years	Consumption 2 years	Consumption mid- childhood	Maternal consumption	Liking 2 years	Consumption 2 years	Consumption mid- childhood	Maternal consumption
Fruits								
Liking at 2 years	1	0.39	0.21	0.11	0.44	0.27	0.18	0.07
Consumption at 2 years, times/d		1	0.39	0.30	0.19	0.40	0.29	0.21
Consumption at mid-childhood, times/d			1	0.26	0.10	0.19	0.32	0.20
Maternal consumption, times/d				1	0.04	0.15	0.12	0.26
Vegetables								
Liking at 2 years					1	0.50	0.27	0.04
Consumption at 2 years, times/d						1	0.40	0.24
Consumption at mid-childhood, times/d							1	0.27
Maternal consumption, times/d								1

Maternal consumption was collected at 6 months postpartum

All *p*-values <0.05 except child fruit liking - maternal vegetable consumption and child vegetable liking - maternal fruit consumption (both *p* = 0.24)

Table 4

Association of child's early liking, early consumption and maternal consumption with mid-childhood consumption of fruits and vegetables. Data from 901 mother-child dyads in Project Viva.

	Adjusted mean difference (95% CI) in mid-childhood fruit and vegetables consumption (times/d) for 1-unit increment in predictor							
	N	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Predictors for mid-childhood fruits consumption								
	893							
Child's early liking [*]		0.34 (0.23, 0.44)			0.12 (0.02, 0.23)	0.30 (0.20, 0.40)		0.12 (0.01, 0.23)
Child's early consumption			0.30 (0.25, 0.35)		0.27 (0.22, 0.33)		0.27 (0.22, 0.32)	0.25 (0.19, 0.30)
Maternal consumption ^φ				0.24 (0.17, 0.30)		0.21 (0.15, 0.28)	0.14 (0.08, 0.21)	0.14 (0.07, 0.20)
R-squared (%)		7.9%	17.0%	8.7%	17.5%	12.0%	18.7%	19.1%
Predictors for mid-childhood vegetables consumption								
	892							
Child's early liking [*]		0.28 (0.22, 0.35)			0.10 (0.03, 0.18)	0.27 (0.21, 0.34)		0.12 (0.05, 0.20)
Child's early consumption			0.29 (0.24, 0.33)		0.25 (0.20, 0.30)		0.25 (0.21, 0.30)	0.21 (0.16, 0.26)
Maternal consumption ^φ				0.24 (0.18, 0.29)		0.23 (0.18, 0.28)	0.16 (0.11, 0.22)	0.17 (0.12, 0.23)
R-squared (%)		10.4%	18.2%	10.2%	19.0%	17.1%	21.4%	22.6%

All models are adjusted for maternal age, pre-pregnancy BMI, race/ethnicity, education, parity, pregnancy smoking status and child age, sex and breastfeeding duration at 1 year

^{*}Liking at 2 years is coded for 1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree

ϕ Maternal consumption was collected at 6-month postpartum

Model 1 = child's early liking

Model 2 = child's early consumption

Model 3 = maternal consumption

Model 4 = child's early liking + child's early consumption

Model 5 = child's early liking + maternal consumption

Model 6 = child's early consumption + maternal consumption

Model 7 = child's early liking + child's early consumption + maternal consumption