Maternal Diet During Pregnancy and Lactation and Child Food Preferences, Dietary Patterns, and Weight Outcomes: a Review of Recent Research

Alison K. Ventura[1] · **Suzanne Phelan**[1] · **Karina Silva Garcia**[1]

Abstract

Purpose of Review Efforts to promote children's preferences for healthy foods hold much potential for improving diet quality and preventing obesity. The purpose of this review was to summarize recent evidence for associations between maternal diet during pregnancy and lactation and child food preferences, dietary patterns, and weight outcomes.

Recent Findings Recent research illustrates greater maternal vegetable intakes during pregnancy and lactation predict greater child preferences for and intakes of vegetables. Recent randomized clinical trials to improve maternal weight outcomes during the perinatal period via behavioral lifestyle interventions that included dietary components have yielded mixed findings for effects on child weight outcomes.

Summary There is strong evidence that maternal diet during pregnancy and lactation shapes flavor preferences during infancy; more research is needed to understand factors that facilitate versus hinder the translation of these preferences to later dietary patterns and weight outcomes.

Keywords Flavor preferences · Food preferences · Pregnancy · Lactation · Dietary patterns · Weight status

Introduction

For the first time in US history, the 2020–2025 Dietary Guidelines for Americans include guidance for pregnant and lactating women and their infants under 2 years of age [1••]. Given the high energy and nutrient demands of pregnancy, lactation, and early growth and development, these guidelines focus on the importance of varied diets high in nutrient-rich foods, with an emphasis on consumption of foods high in iron and zinc, such as meats, seafood, legumes, whole grains, and dark green leafy vegetables. The 2020–2025 Dietary Guidelines also acknowledge excess consumption of foods high in added sugars, saturated fat, and sodium can interfere with abilities to meet food group recommendations; thus, consumption of these foods should be limited. High diet quality during these sensitive periods of development establishes a healthy foundation for the infant's later growth and development and is associated with lower risk for obesity and related chronic diseases [2, 3].

Recent research illustrates children's diets are in need of improvement. Data from the 2016 Feeding Infants and Toddlers Study (FITS 2016) illustrate that approximately 30% of children 1–4 years of age fail to consume even one serving of vegetables on a daily basis [4•]. Among those that do consume vegetables, French fries and other fried potatoes are the "vegetable" most frequently consumed [5]. In addition, the daily intakes of most young children (75–85%) do not include nutrient-dense dark green and deep yellow vegetables and ~ 40% of children do not include whole grain-rich foods [5]. In contrast, the vast majority of young children (80–90%) consume desserts, sweets, or sweetened beverages on a daily basis [5], which increases their short- and long-term risks of obesity and related diseases. Given dietary patterns and child weight track from childhood into adolescence [6], it is not surprising that these trends remain, and worsen, during older childhood and adolescence [7, 8].

✉ Alison K. Ventura
akventur@calpoly.edu

[1] Department of Kinesiology and Public Health, Center for Health Research, California Polytechnic State University, One Grand Ave, San Luis Obispo, CA 93407, USA

These trends are concerning, but not entirely unexpected given humans exhibit inborn predispositions to prefer sweet, savory, and salty tastes and dislike bitter and, to a certain extent, sour tastes [9], which likely reflects evolutionary needs to be attracted to foods that are good sources of calories, protein, or essential minerals (e.g., sweet breast milk and calorie-rich carbohydrates, savory meats, salt, respectively) and repelled by foods with taste qualities that signal potential harm (e.g., bitter poisonous plants, sour acids) [10]. These tastes, which are limited to the 5 basic tastes (sweet, savory, salty, bitter, and sour) sensed via taste receptors in the oral cavity, contribute to the experience of flavor, which occurs via integrated processing of tastes and odors. Young children are hedonistic eaters whose food selection patterns are primarily driven by taste and flavor preferences, but also familiarity [11]. This is especially true during the sensorimotor and preoperational stages of cognitive development wherein children predominantly experience and process their environments through sensory systems and abilities for processing higher-order, abstract concepts, such as the health value of foods, are limited [12]. Thus, the dietary patterns of today's children reflect the tastes that they innately prefer and, therefore, readily accept and consume. A primary challenge for parents, practitioners, and researchers alike is to shape the early feeding environment in a way that promotes children's preferences for nutrient-rich foods and deemphasizes the intrinsic attractiveness of foods high in sugar, saturated fat, and salt.

Fortunately, young children exhibit high levels of plasticity during the sensitive periods of infancy and early childhood and are primed to learn from and adapt to their early environments. Primary mechanisms by which children learn to prefer novel or initially disliked flavors or foods are associative conditioning, repeated exposure, variety exposure, and social modeling. During associative conditioning, children more readily accept a novel flavor or food when it is paired with a preferred flavor or food compared to when it is introduced alone. For example, experimental research illustrates infants exhibit greater acceptance of infant cereal prepared with breast milk compared to cereal prepared with water during the introduction of complementary foods and beverages [13], and older children are more willing to try vegetables when they are paired with a creamy dip compared to when they are offered alone [14]. Repeated exposure is defined as recurrent experiences with a flavor or food that make it more familiar; experimental research illustrates that 8 to 10 (or more) exposures may be required to increase children's preferences for novel foods [15, 16], but that repeated exposure appears to be the most effective way to promote preferences [17]. In addition, repeated exposure to a variety of foods with similar qualities (e.g., peas, potatoes, squash) promotes acceptance of similar foods to which the infant has not yet been introduced (e.g., carrots) [18]. Early learning is especially potent when embedded within social interactions with the mother and other caregivers [19, 20]; thus, children are sensitive to social modeling and exhibit greater willingness to try foods that they observe caregivers or peers consuming [21, 22].

Interestingly, the development of children's food preferences and risk for obesity begins long before the infant experiences his or her first spoonful of solid foods. Via a form of "biological parenting" [23], flavors from the mother's diet are transmitted to the infant through the amniotic fluid [24] and breast milk [25-29] and create impactful experiences of associative conditioning and repeated exposure to a variety of flavors that shape the child's later food preferences [28, 30••]. Continuity in chemosensory components of amniotic fluid and breast milk helps the neonate transition from womb to world [20] and facilitates a type of chemosensory communication between mother and infant that promotes the infant's receptiveness to and acceptance of the diet of the family and culture at weaning. Other research has shown that maternal obesity, excess weight gain, and higher prenatal sugar [31] and fat intake [32, 33] during pregnancy may increase offspring risk of obesity and other diseases, likely via fetal programming and/or through sharedpostnatal social-environmental contexts.

The purpose of this review is to summarize recent research illustrating effects of maternal diet during pregnancy and lactation on child food preferences, dietary patterns, and weight status. Several excellent reviews have recently been published on this topic, including a systematic review that contributed to the development of Dietary Guidelines for pregnant and lactating women and infants [34-40]. Therefore, the present review will emphasize the most recent human research published since 2016, with a specific focus on providing recommendations for future research and practice.

Effects of Maternal Diet During Pregnancy and Lactation on Child Food Preferences

Odor volatiles that contribute to the flavors of foods from the mothers' diet are initially transmitted to the fetus via the amniotic fluid [24]. By the third trimester, the fetus responds to chemosensory changes in the composition of the amniotic fluid by increasing [41] or decreasing [42] frequency of swallowing, suggesting that the taste and smell systems are functional prior to birth. Transmission of flavors from the mothers' diet to the infant continues after birth via breast milk [29] and infants similarly respond to changes in the flavor of breast milk by increasing or decreasing their suckling behavior [25-27].

Evidence from experimental research illustrates these exposures shape food preferences in that infants exhibit

preferences for foods containing flavors to which they were repeatedly exposed via the amniotic fluid or breast milk [28, 30••, 43-45]. In addition, several studies note that breastfed infants are initially more accepting of novel foods compared to formula-fed infants and exhibit greater increases in preferences in response to repeated and variety exposures [15, 46, 47]. Thus, breastfeeding may serve as a "flavor bridge" [48], wherein flavor preferences developed in utero are strengthened and expanded in preparation for the infant's eventual weaning onto the foods of the family and culture (Fig. 1).

To our knowledge, no recent studies (within the past 5 years) have examined impacts of prenatal flavor exposures on child flavor and food preferences. Table 1 presents recent studies examining associations between maternal diet during lactation and child preferences. Data from a recent clinical trial conducted by Mennella and colleagues [30••] suggested that during lactation, exposure timing may be more impactful than duration. Within this trial, 75 lactating mothers were randomized to one of five groups. Four experimental groups were randomized to regularly consume a variety of vegetable juices (carrot, beet, celery, and mixed vegetable) for either 3 consecutive months (0.5–3.5 months postpartum) or for 1 month starting at 0.5 month, 1.5 months, or 2.5 months postpartum. The control group consumed water and refrained from consuming the juices between postpartum months 0.5–3.5. Infants' acceptance of plain, carrot-, and broccoli-flavored cereals were assessed when infants were 6–8 months of age. Infants whose mothers consumed the juices between 0.5 and 1.5 months consumed significantly more carrot flavored cereal than infants in the control group; no differences were seen between control and infants exposed between months 1.5 and 2.5 or 2.5 and 3.5, and duration (3 months versus 1 month) did not heighten effects of exposure on infants' preferences. In addition, no effects of exposure were seen for intake or rate of feeding of plain or broccoli-flavored cereals. Of note, mothers' repeated exposures to the vegetable juices increased their own liking of these juices over time, suggesting that repeated variety exposure may promote vegetable acceptance for mothers and infants alike.

For the most part, previous work has focused on how mothers' intake of a single food (e.g., carrots) or type of food (e.g., vegetable juices) impacted infants' later food preferences [28, 30••, 43, 44]. A recent prospective observational study by Wagner and colleagues [49•] examined whether mothers' dietary patterns during pregnancy and lactation predicted infants' preferences for an array of pleasant versus unpleasant food odors at 8 and 12 months of age. Pleasant food odors included vanillin, apple, peach/apricot, and strawberry and unpleasant food odors included trimethylamine (fish), butyric acid (butyric cheeses), dimethyl disulfide (sulfurous cheeses and sulfurous vegetables), and 2-isobutyl-3-methoxypyrazine (green vegetables). At 8 months, greater consumption of green vegetables during pregnancy and lactation for mothers predicted greater liking of the odor of green vegetables for infants. Marginally significant associations were seen between infants' preferences for sulfurous cheeses and fish odors and mothers' intakes of these foods during pregnancy and lactation, respectively. No associations were seen between maternal diet and infant preferences for pleasant odors at 8 months, and none of the noted associations at 8 months were significant at 12 months. Taken together, these findings suggest that the mother's diet during pregnancy and lactation may be especially impactful for promoting preferences for foods that are not typically paired with sweet taste and with intrinsically unpleasant flavors, but that direct associations between prenatal and lactation dietary exposures and infant preferences fade once the infant's exposures expand via solid food feeding. However, additional research is needed to verify this interpretation given other studies suggest maternal diet during pregnancy and lactation predicts children's food preferences at ages 1–3 years [50] and 8–9 years of age [51].

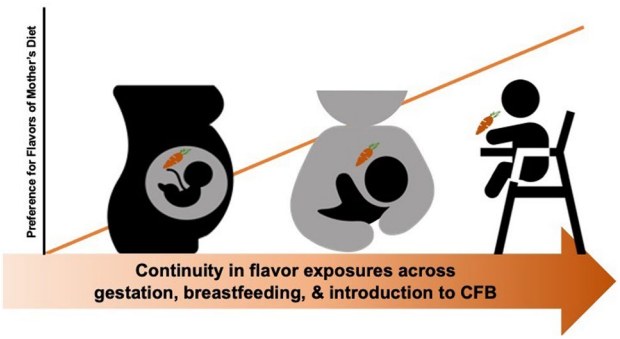

Fig. 1 Continuity of flavor exposures within amniotic fluid, breast milk, and complementary foods and beverages (CFB) promotes children's preferences for those flavors via repeated exposure, variety exposure, and associative conditioning

Associations Between Maternal Diet During Pregnancy and Lactation and Child Dietary Patterns

Children's flavor and food preferences are strong predictors of intake and dietary patterns [e.g., 52, 53]. Thus, it is hypothesized that positive effects of maternal perinatal diet on child preferences would subsequently promote greater diet variety and quality for children. To our knowledge, no recent experimental research has tested this hypothesis; recent observational research demonstrates somewhat equivocal findings (Table 1).

Associations Between Maternal Diet During Pregnancy and Child Dietary Patterns. Yuan and colleagues [54]

Table 1 Studies published between 2016 and 2021 that investigated associations between maternal diet during pregnancy and/or lactation and child preferences and dietary patterns

Reference	Study design	Sample size	Location	Maternal diet exposure	When did diet exposure occur?	Child outcome measure	Child age at outcome assessment	Key findings
Outcome: Child flavor and food preferences								
Mennella et al. [30••]	Randomized clinical trial	97 dyads	Philadelphia, PA, USA	Consumption of a variety of vegetable juices (carrot, celery root, beet, mixed vegetables)	Lactation	Observed acceptance of plain vs. carrot-flavored vs. broccoli-flavored cereal at weaning Acceptance defined as greater amounts consumed, faster rate of feeding, and fewer negative facial expressions	7–8 mo	• Infants whose mothers consumed the juices were more accepting of the carrot-flavored cereal than infants whose mothers did not consume the juices • Timing of exposure (0.5 mo vs. 1.5 mo vs 2.5 mo postpartum) was more important than duration of exposure (3 mo vs. 1 mo) for promoting acceptance of carrot-flavored cereal • Exposure to juices did not impact acceptance of broccoli-flavored cereal
Uwaezuoke et al. [50]	Cross-sectional	220 dyads	Enugu, South-East Nigeria	Self-reported frequency of consumption of flour-based snacks (doughnut, meat pie, oven baked) and staple foods (boiled yams, dried cassava)	Lactation	Mother-reported frequency of consumption of flour-based snacks and stable foods	1–6 y	• Mothers' greater consumption of flour-based snacks during lactation was associated with significantly greater odds of the child preferring flour-based snacks • Associations between mothers' consumption of staple foods during lactation and children's later preferences for these foods were not significant
Wagner et al. [49•]	Prospective cohort	100 dyads	Dijon, France	Self-reported intakes of vanilla desserts, apple products, peach/apricot products, strawberry products, fish, cheeses, and vegetables	Pregnancy and lactation	Observed preferences for pleasant (vanilla, apple, peach/apricot, strawberry) versus unpleasant (fish, butyric cheeses, sulfurous cheeses, sulfurous vegetables, green vegetables) food odors Preferences defined as greater duration of mouthing behavior	8 mo 12 mo	• Greater consumption of green vegetables during pregnancy and lactation for mothers predicted greater liking of green vegetable odor at 8 mo for infants • No associations between maternal diet and infant odor preferences were seen when infants were 12 mo
Outcome: Child dietary patterns								

Table 1 (continued)

Reference	Study design	Sample size	Location	Maternal diet exposure	When did diet exposure occur?	Child outcome measure	Child age at outcome assessment	Key findings
Yuan et al. [54]	Prospective cohort	1275 dyads at 8 mo 1219 dyads at 12 mo	Nancy and Poitiers, France	Self-reported via a FFQ FFQ data used to determine dietary patterns	Pregnancy	Reported by mother via 3-day food records Analysis focused on: • Total daily Carbohydrate intake (g/d) • Total daily fat intake (g/d) • Consumption of added sugar (yes vs. no) • Consumption of added fat (yes vs. no)	8 mo 12 mo	• Greater maternal adherence to a "Healthy" dietary pattern during pregnancy was associated with higher likelihood of the child being a consumer of added sugar at 8 mo • Greater maternal adherence to a "Western" dietary pattern was associated lower likelihood that the infant was a consumer of added fats at 8 mo but greater percentage of energy intake from carbohydrates for infants at 12 mo
Ashman et al. [55]	Prospective cohort	52 dyads	Newcastle, New South Wales, Australia	Self-reported via a FFQ FFQ data used to determine diet quality and fruit and vegetable intakes	Pregnancy Concurrent with child assessment	Reported by mother via the ACAES ACAES data used to determine diet quality and fruit and vegetable intakes	2–3 y	• Greater maternal diet quality and higher fruit and vegetable intakes during pregnancy were associated with greater child diet quality and higher fruits and vegetable intakes • Mothers' concurrent diet quality mediated associations between prenatal diet quality and children's intake of fruits and vegetables
Bjerregaard [56]	Prospective cohort	19,582 dyads	Denmark	Self-reported via a FFQ FFQ data used to determine diet quality	Pregnancy Concurrent with child assessment	Reported by mother via a FFQ FFQ data used to determine diet quality	14 y	• High maternal diet quality during pregnancy predicted likelihood of high diet quality for children • Adjustment for mothers' concurrent diet quality did not attenuate associations between diet quality during pregnancy and child diet quality
Okubo et al. [69]	Prospective cohort	763 dyads	Neyagawa City, Osaka Prefecture, Japan	Self-reported via a DHQ DHQ data used to determine fruit and vegetable intakes	Pregnancy	Reported by mother via a FFQ FFQ data used to determine fruit and vegetable intakes	16–24 mo	• Children BF for ≥ 6 mo had lower odds of low vegetable intake compared to infants BF for < 6 mo • Adjustment for maternal vegetable intake during pregnancy did not attenuate this association, but greater maternal vegetable intake during pregnancy predicted lower odds of low vegetable intake for children • The association between BF duration and child fruit intake was not significant

Table 1 (continued)

Reference	Study design	Sample size	Location	Maternal diet exposure	When did diet exposure occur?	Child outcome measure	Child age at outcome assessment	Key findings
Beckerman et al. [70••]	Prospective cohort	1396 dyads	USA	Self-reported daily intake of fruits and vegetables	Lactation	Mother-reported daily intakes of fruit and vegetable	12 mo 6 y	• At 12 mo, children who were BF $\geq$ 16 wk had greater odds of high fruit and vegetable intakes than children who were BF $<$ 16 wk • At 6 years, the combination of BF $\geq$ 16 wk and greater maternal vegetable intake during lactation predicted greater odds of high vegetable intake for the child

ACAES Australian Child and Adolescent Eating Survey, *BF* breastfed, *DHQ* Diet History Questionnaire, *FFQ* Food Frequency Questionnaire

examined whether mothers' adherence to "Healthy" versus "Western" dietary patterns during pregnancy predicted infant intakes of added sugars, added fats, or overall carbohydrates or fats at 8 and 12 months of age. Greater maternal adherence to a "Healthy" dietary pattern during pregnancy was associated with higher likelihood of the child being a consumer of added sugar at 8 months, but no dietary factors at 8 or 12 months of age. Greater maternal adherence to a "Western" dietary pattern was associated lower likelihood that the infant was a consumer of added fats at 8 months but greater percentage of energy intake from carbohydrates for infants at 12 months. Thus, this study did not clearly support the hypothesis that healthier maternal diet during pregnancy predicted healthier child dietary patterns during infancy, but a limitation of this study was that mothers' concurrent diet was not assessed and several other factors, such as age at introduction of solid foods and mothers' use of ready-prepared versus homemade baby foods, were significant predictors of infant dietary patterns, making it unclear whether associations between mothers' dietary patterns during pregnancy and infants' later added sugar, added fat, and carbohydrates reflected impacts of pregnancy diet on child diet or broader effects of unmeasured covariates such as the home food environment or maternal feeding attitudes and practices.

Ashman and colleagues [55] examined associations between maternal diet quality during pregnancy and child fruit and vegetable intake at 2–3 years of age in a sample of 52 Australian mother–child dyads. Significant stability in mothers' prenatal and postnatal diet quality was observed and, although prenatal diet quality was positively associated with children's intake of fruits and vegetables at 2–3 years of age, mothers' concurrent diet quality (when children were 2–3 years of age) mediated these associations. Thus, this study did not identify a direct association between maternal pregnancy diet and child diet, but rather associations that were explained by stability in mothers' diets from pregnancy to early childhood and similarities in the concurrent diets of mothers and children.

Bjerregaard and colleagues [56] similarly examined associations between mothers' diet quality during pregnancy and children's diet quality at age 14 years in a sample of ~ 20,000 mother–child pairs in the Danish National Birth Cohort. High maternal diet quality during pregnancy significantly predicted high diet quality for children at age 14 years, and this association remained significant even when controlling for maternal age; pre-pregnancy body mass index (BMI); alcohol use, smoking, and physical activity level during pregnancy; breastfeeding duration; parity; and education level. Despite a high correlation between concurrent diet quality of mothers and children when children were 14 years of age, associations between maternal prenatal diet quality and child diet quality

remained significant even after controlling for mothers' concurrent diet quality. Thus, in contrast to Ashman and colleagues' findings [55], these findings suggest the predictive value of maternal prenatal diet was over and above that of relevant covariates and associations between concurrent intakes of mothers and children.

Associations Between Maternal Diet During Lactation and Child Dietary Patterns. Although several recent observational studies suggest longer breastfeeding duration predicts higher diet quality during later childhood [57-70••], very few of these studies also included measures of maternal diet during lactation orconcurrent with child diet assessment [60, 69, 70••]. Thus, it is difficult to parse out the extent to which identified associations between longer breastfeeding durations and greater child diet quality are attributable to flavor learning during breastfeeding versus to confounding factors, such as maternal education, family socioeconomic status, and overall healthier home environments, that would increase children's likelihood of both being breastfed and having greater access to healthier foods. However, two recent studies illustrated that longer breastfeeding duration predicted greater vegetable intakes for children between 18 and 24 months of age, even after controlling for relevant sociodemographics and mothers' vegetable intakes during pregnancy [69], and greater frequency of fruit consumption and consumption of a greater variety of fruits and vegetables for children between 2 and 12 years of age, even after controlling for relevant sociodemographics and mothers' concurrent fruit and vegetable intakes [60].

Beckerman and colleagues [70••] explored whether maternal diet during early infancy interacted with breastfeeding duration to predict child fruit and vegetable intakes at 12 months and 6 years of age in a sample of 1463 mother-infant dyads in the USA. Analyses controlled for a wide range of covariates representing maternal sociodemographics, child characteristics, involvement of non-maternal caregivers, barriers and facilitators to breastfeeding, the child's food environment, and maternal health status. When children were 12 months of age, longer breastfeeding duration was associated with higher child fruit and vegetable consumption, but interactions between mothers' fruit or vegetable intakes during lactation and breastfeeding duration were not significant. However, when children were 6 years of age, the interaction between mothers' vegetable intakes during lactation and breastfeeding duration was significant, with the combination of greater maternal vegetable intakes and longer breastfeeding duration predicting higher vegetable intakes for children at age 6 years. Thus, these findings, although limited by the correlational nature of the data, support the hypothesis that flavor exposures via the mother's diet during lactation promotes greater intakes of vegetables during later childhood.

Associations Between Maternal Diet During Pregnancy and Lactation and Child Weight Outcomes

To our knowledge, very few recent studies have directly examined associations between maternal diet during pregnancy or lactation and later child weight outcomes. Several recent randomized clinical trials have attempted to improve mothers' pregnancy and postpartum weight outcomes via behavioral lifestyle interventions that included dietary components (Table 2). Although these studies do not allow for an isolation of effects of maternal diet during pregnancy and lactation on child weight outcomes, these studies provide some insight into how alterations to mothers' diets, physical activity, and weight may predict children's later weight status and obesity risk.

Maternal Prenatal Diet and Child Weight. Maternal obesity, excess weight gain [71-76], and related poor prenatal diet quality [32, 33, 77] are prevalent during pregnancy in most Western countries and may affect later child development of obesity and related chronic diseases. Observational literature and developmental origins of disease hypothesis would suggest that improving maternal diet quality and reducing excess calorie intake and weight gain during pregnancy should lower offspring risk of obesity [78, 79], but clinical trial data have yielded mixed results [80]. Some positive effects were observed in a UK-based prenatal intervention that reduced mothers' dietary glycemic load and gestational weight gain; the prenatal intervention reduced infant adiposity at 6 months [81] and had suggestive effects of lower odds of overweight/obesity at 3 years [82]. However, other research has shown no effect of prenatal lifestyle interventions on offspring growth. The LIFE-Moms [83••] consortium of randomized clinical trials tested a variety of dietary interventions to reduce excess gestational weight gain (e.g., the DASH diet, MyPlate, meal replacements) in women with overweight or obesity. Some of the interventions effectively improved mothers' diet quality, including significant increases in Healthy Eating Index Scores and micronutrient intake reported in two studies [84, 85], and also reduced excess gestational weight gain but no significant effects were observed on child Body Mass Index *z*-scores (BMIz) at 12 months [83••, 86]. Longer term follow-up of the lifestyle intervention that included meal replacements indicated that even though the prenatal intervention significantly improved maternal micronutrient status during pregnancy [85], it had no significant effect on offspring BMIz through 3 years [87].

Table 2 Randomized clinical trials published between 2016 and 2021 that examined effects of perinatal diet and lifestyle interventions on child anthropometrics

Reference	Trial name	Sample size	Location	Intervention	Child weight status measure	Child age at weight status assessment	Key findings
Patel et al. [81]	UPBEAT	698 dyads	UK	Lifestyle intervention focused on reducing GDM risk in pregnant women with overweight or obesity via reducing dietary glycemic index load and saturated fat intake and increasing physical activity	Skinfold thicknesses	6 mo	• Intervention reduced mothers' dietary glycemic index scores, saturated fat intake, and energy intake during pregnancy and at 6 mo postpartum • Intervention was associated with lower subscapular skinfold thickness z-scores for infants
Dalrymple et al. [82]	UPBEAT	514 dyads	UK	Lifestyle intervention focused on reducing GDM risk in pregnant women with overweight or obesity via reducing dietary glycemic index load and saturated fat intake and increasing physical activity	Skinfold thicknesses BMIz	3 y	• Intervention reduced mothers' dietary glycemic index, saturated fat intake, and energy intake through 3 y postpartum • Intervention had no significant effect on infant skinfolds or BMIz
Phelan et al. [83••]	LIFE-Moms Consortium	1150 dyads	7 sites across the United States	Interventions varied; all aimed to reduce excess GWG among pregnant women with overweight or obesity via dietary, physical activity, and behavioral strategies	Skinfold thicknesses WLZ	12 mo	• Interventions reduced excess GWG and postpartum weight retention for mothers • Interventions had no significant effect on infant skinfolds or WLZ
Vesco et al. [86]	Healthy Moms	114 dyads	Northwest OR and Southwest WA	Lifestyle intervention focused on reducing excess GWG among pregnant women with overweight or obesity via the DASH diet, increased physical activity levels, and behavioral strategies	WAZ WLZ	12 mo	• Intervention reduced excess GWG but not postpartum weight retention for mothers • Intervention was associated with lower infant WAZ scores • Intervention had no significant effect on infant adiposity or WLZ

Table 2 (continued)

Reference	Trial name	Sample size	Location	Intervention	Child weight status measure	Child age at weight status assessment	Key findings
Phelan et al. [87]	Healthy Beginnings/ Comienzos Saludables	264 dyads	San Luis Obispo, CA and Providence, RI	Lifestyle intervention focused on reducing GWG among pregnant women with overweight or obesity via meal replacements, increased physical activity, and behavioral strategies	Skinfold thicknesses BMIz	3 y	• Intervention reduced excess GWG but not postpartum weight retention for mothers • Intervention had no significant effect on infant skinfolds or BMIz
Kolu et al. [88]	n/a	173 dyads	Finland	Lifestyle intervention focused on reducing GDM risk among at-risk pregnant women via healthy eating, physical activity, and behavioral strategies	BMI-for-age	7 y	• Intervention had no significant effect on infant BMI-for-age • Intervention adherers vs. non-adherers had infants with significantly lower BMI-for-age
Phelan et al. [85]	FIT Moms/Mamas Activas	333 dyads	12 WIC clinics in CA	Internet-based lifestyle intervention to reduce postpartum weight retention among new mothers via healthy eating, physical activity, and behavioral strategies	BMIz	~11 mo (6 mo post study entry) ~17 mo (12 mo post study entry)	• Intervention reduced postpartum weight and waist circumference for mothers • Intervention reduced infant BMIz between study entry and 6 mo but not after 12 mo

BMIz body mass index *z*-score; *GDM* gestational diabetes mellitus; *GWG* gestational weight gain; *LIFE-Moms* Lifestyle Interventions for Expectant Moms; *UPBEAT* UK Pregnancies Better Eating and Activity Trial; *WAZ* weight-for-age *z*-scores, *WIC* Special Supplemental Nutrition Program for Women, Infants, and Children; *WLZ* weight-for-length *z*-scores; *n/a* not available

To affect early metabolic imprinting and child obesity, more intensive prenatal interventions might be needed that bolster dietary adherence and promote greater reductions in maternal gestational weight gain [88]. Alternatively, interventions may need to be initiated preconceptually [89, 90] and/or continue to target maternal weight management during the postpartum years [91] to exert a positive enduring effect on reducing child weight status.

Maternal Postpartum Diet and Child Weight Outcomes. After birth, mothers' dietary patterns and weight status may also play a role in shaping child weight status. Although it is plausible that effects of maternal diet during lactation on child food preferences and dietary patterns translate to healthier weight outcomes [92], very few human studies have directly examined whether maternal diet during lactation and related changes in breast milk composition impact child weight outcomes [93, 94]. However, maternal postpartum diet (during lactation and beyond) could impact child diet and weight outcomes through a variety of mechanisms, including through social modeling and by shaping the home food environment. Mothers influence about 87% of household meals and spend 40 to 50 hours per week with their infants [95]. Mothers also establish the home eating environment and model eating and activity behaviors that children may learn to emulate [96-99].

Clinical trial data studying the effects of maternal postpartum diet and weight loss interventions on child weight status remain scant. However, in a recent cluster randomized trial of 371 postpartum mothers in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), an internet-based weight loss program had a positive "ripple" effect on the BMIz of infants in the home [100]. Infants (aged 5.3 months on average) of intervention vs. control group mothers exhibited lower BMIz change from study entry through 6 months (0.23 vs 0.65 BMIz change, respectively; $p=0.001$). This pattern held true regardless of infant age, ethnicity, sex, or breastfeeding status but was not significant through 12 months of intervention ($p=0.16$). Additional research is needed to determine whether and how maternal diet and weight loss interventions during the postpartum years could have a positive ripple effect on child weight status [101]. Alternatively, combining maternal postpartum intervention with an effective pediatric preventive intervention [102] may optimally promote healthy eating and prevent obesity in children.

Conclusions

The promotion of healthy dietary patterns during early childhood is an important foundation for obesity prevention efforts. Currently, young children's diets contain too few health-promoting dark green and orange vegetables and too much fat, sugar, and salt. Preferences are a primary driver of young children's dietary patterns; thus, efforts to promote preferences for healthy foods hold much potential for improving diet quality and preventing obesity.

Research summarized in this review illustrates the development of food preferences begins long before solid foods are introduced. There is strong experimental evidence illustrating flavors of the mother's diet appear in the amniotic fluid and breast milk, creating experiences of repeated exposure, variety exposure, and associative conditioning that shape the infant's early flavor preferences. These findings highlight the importance of supporting mothers' efforts to eat healthfully during pregnancy but also emphasize the importance of supporting mothers' breastfeeding intentions and goals because formula-feeding likely disrupts the odor and flavor bridges that help infants transition from womb to world and from breast to table.

Direct effects of maternal diet during pregnancy and lactation on child preferences and dietary patterns may fade once the child's array of dietary exposures increases; however, the present review revealed that very few recent studies have assessed how effects of maternal diet during pregnancy or lactation on child food preferences may translate to later dietary patterns and weight outcomes. Effective parent feeding practices are likely needed to continue promoting children's flavor learning and preferences for healthy foods, especially as children enter the neophobic phase (between 2 and 6 years) where previously accepted foods are rejected and diet variety and quality decline rapidly [103•]. Indeed, many parents indicate that they struggle to employ repeated exposure with their young children and that it is difficult to limit energy-dense foods after they have been introduced [104]. Research and interventions are needed to understand how to best "extend the bridge" through the weaning and neophobic phases to ensure the establishment of healthy dietary patterns during early childhood.

In addition, it is important to note that influences between parents and children are bidirectional; although the focus of this review was on influences of mothers' diets on children's eating and weight outcomes, children's food acceptance and preferences also influence the types of foods their parents continue to offer and make available in the home. Given evidence that repeated exposure to vegetables can increase liking of the taste of vegetables for mothers and children alike [30], efforts to improve the quality of mothers' diets during pregnancy and lactation may help increase mothers' preferences for healthy foods but also increase the likelihood that these changes will be sustained once her infant also exhibits acceptance of and preferences for the foods offered.

In conclusion, to improve child diet quality and related health outcomes, mothers' diets also need to be addressed [55, 57, 105]. Reducing excess calorie intake and improving diet quality of mothers during and after pregnancy holds

potential for positively shaping child eating and related weight outcomes through effects on the flavor milieu of the amniotic fluid and breast milk, as well via effects of social modeling and the home food environment. Key targets for public health interventions are (1) promoting healthy dietary intakes and rates of gestational weight gain for mothers during pregnancy, (2) promoting breastfeeding and continued healthy eating for mothers during lactation, and (3) educating parents about the importance of repeated exposure and variety exposure during the introduction to complementary foods and beverages, prior to the neophobic phase, to sustain and engrain the food preferences that have been established during the perinatal period. Future clinical trial research is needed to determine the optimal timing and content of such interventions.

Compliance with Ethical Standards

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

Conflict of Interest Statement Alison K. Ventura declares that she has no conflict of interest. Suzanne Phelan has received research funding from WW International (unrelated to this work) to study factors related to long-term weight control. Karina Silva Garcia declares that she has no conflict of interest.

References

Papers of particular interest, published recently, have been highlighted as:
• Of importance
•• Of major importance

1.•• U.S. Department of Agriculture, U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2020–2025. 9th Edition. December 2020. Available at DietaryGuidelines.gov. **The 2020–2025 Dietary Guidelines were recently released and provide excellent dietary guidance for pregnant and lactating women and infants up to 2 years. These guidelines reflect the current evidence-base regarding the quality and quantity of foods needed to promote healthy growth and development during these critical windows of development.**
2. Pool LR, Aguayo L, Brzezinski M, Perak AM, Davis MM, Greenland P, et al. Childhood risk factors and adulthood cardiovascular disease: a systematic review. J Pediatr. 2021.
3. Salam RA, Padhani ZA, Das JK, Shaikh AY, Hoodbhoy Z, Jeelani SM, et al. Effects of lifestyle modification interventions to prevent and manage child and adolescent obesity: a systematic review and meta-analysis. Nutrients. 2020;12(8):2208.
4.• Roess AA, Jacquier EF, Catellier DJ, Carvalho R, Lutes AC, Anater AS, et al. Food consumption patterns of infants and toddlers: findings from the Feeding Infants and Toddlers Study (FITS) 2016. J Nutr. 2018;148(suppl_3):1525S-35S. **The Feeding Infants and Toddlers Study (FITS) provides comprehensive data on the dietary patterns of young children in the USA.**
5. Welker EB, Jacquier EF, Catellier DJ, Anater AS, Story MT. Room for improvement remains in food consumption patterns of young children aged 2–4 years. J Nutr. 2018;148(suppl_3):1536S-46S.
6. Nicklaus S, Remy E. Early origins of overeating: tracking between early food habits and later eating patterns. Curr Obes Reports. 2013;2(2):179–84.
7. Wambogo EA, Ansai N, Ahluwalia N, Ogden CL. Fruit and vegetable consumption among children and adolescents in the United States, 2015–2018. NCHS Data Brief. 2020;no. 391 Hyattsville, MD: National Center for Health Statistics.
8. Reedy J, Krebs-Smith SM. Dietary sources of energy, solid fats, and added sugars among children and adolescents in the United States. J Am Diet Assoc. 2010;110(10):1477–84.
9. Steiner JE. Human facial expressions in response to taste and smell stimulation. Adv Child Dev Behav. 1979;13:257–95.
10. Cowart BJ. Taste, our body's gustatory gatekeeper. Cerebrum. 2005:7–22.
11. Aldridge V, Dovey TM, Halford JCG. The role of familiarity in dietary development. Dev Rev. 2009;29(1):32–44.
12. Rohlfs Domínguez P. New insights into the ontogeny of human vegetable consumption: From developmental brain and cognitive changes to behavior. Dev Cogn Neurosci. 2020;45:100830-.
13. Mennella JA, Beauchamp GK. Mothers' milk enhances the acceptance of cereal during weaning. Pediatr Res. 1997;41(2):188–92.
14. Anzman-Frasca S, Savage JS, Marini ME, Fisher JO, Birch LL. Repeated exposure and associative conditioning promote preschool children's liking of vegetables. Appetite. 2012;58(2):543–53.
15. Sullivan SA, Birch LL. Infant dietary experience and acceptance of solid foods. Pediatrics. 1994;93(2):271–7.
16. Barends C, de Vries JH, Mojet J, De Graaf C. Effects of repeated exposure to either vegetables or fruits on infant's vegetable and fruit acceptance at the beginning of weaning. Food Qual Prefer. 2013;29:157–65.
17. Bouhlal S, Issanchou S, Chabanet C, Nicklaus S. 'Just a pinch of salt'. An experimental comparison of the effect of repeated exposure and flavor-flavor learning with salt or spice on vegetable acceptance in toddlers. Appetite. 2014;83(209–217).
18. Coulthard H, Harris G, Fogel A. Exposure to vegetable variety in infants weaned at different ages. Appetite. 2014;78:89–94.
19. Vygotsky LS. Mind in society: the development of higher psychological processes. Cambridge, MA: Harvard University Press; 1978.
20. Schaal B, Saxton TK, Loos H, Soussignan R, Durand K. Olfaction scaffolds the developing human from neonate to adolescent and beyond. Philos Trans R Soc Lond B Biol Sci. 1800;2020(375):20190261.
21. Addessi E, Galloway AT, Visalberghi E, Birch LL. Specific social influences on the acceptance of novel foods in 2-5-year-old children. Appetite. 2005;45(3):264–71.
22. Hendy HM. Effectiveness of trained peer models to encourage food acceptance in preschool children. Appetite. 2002;39(3):217–25.
23. Lane M, Robker RL, Robertson SA. Parenting from before conception. Science. 2014;345(6198):756–60.
24. Mennella JA, Johnson A, Beauchamp GK. Garlic ingestion by pregnant women alters the odor of amniotic fluid. Chem Senses. 1995;20(2):207–9.
25. Mennella JA, Beauchamp GK. Maternal diet alters the sensory qualities of human milk and the nursling's behavior. Pediatrics. 1991;88(4):737–44.

26. Mennella JA, Beauchamp GK. The effects of repeated exposure to garlic-flavored milk on the nursling's behavior. Pediatr Res. 1993;34(6):805–8.
27. Mennella JA, Beauchamp GK. The human infants' response to vanilla flavors in mother's milk and formula. Infant Behav Devel. 1996;19(1):13–9.
28. Mennella JA, Jagnow CP, Beauchamp GK. Prenatal and postnatal flavor learning by human infants. Pediatrics. 2001;107(6):E88.
29. Hausner H, Bredie WL, Molgaard C, Petersen MA, Moller P. Differential transfer of dietary flavour compounds into human breast milk. Physiol Behav. 2008;95(1–2):118–24.
30.●● Mennella JA, Daniels LM, Reiter AR. Learning to like vegetables during breastfeeding: a randomized clinical trial of lactating mothers and infants. Am J Clin Nutr. 2017;106(1):67–76. **Mennella has made a major contribution to this field through rigorous and elegant experimental studies examining effects of maternal diet during pregnancy and lactation on infant behavior and preferences. This experiment is an extension of Mennella's previous research examining how maternal diet during pregnancy shapes infants' flavor preferences.**
31. Phelan S, Hart C, Phipps M, Abrams B, Schaffner A, Adams A, et al. Maternal behaviors during pregnancy impact offspring obesity risk. Exp Diabetes Res. 2011;2011:985139.
32. Murrin C, Shrivastava A, Kelleher CC, Lifeways Cross-generation Cohort Study Steering G. Maternal macronutrient intake during pregnancy and 5 years postpartum and associations with child weight status aged five. Eur J Clin Nutr. 2013;67(6):670–9.
33. Niinisto S, Takkinen HM, Uusitalo L, Rautanen J, Nevalainen J, Kenward MG, et al. Maternal dietary fatty acid intake during pregnancy and the risk of preclinical and clinical type 1 diabetes in the offspring. Br J Nutr. 2014;111(5):895–903.
34. Paroche MM, Caton SJ, Vereijken CMJL, Weenen H, Houston-Price C. How infants and young children learn about food: a systematic review. Front Psych. 2017;8.
35. Spahn JM, Callahan EH, Spill MK, Wong YP, Benjamin-Neelon SE, Birch LL, et al. Influence of maternal diet on flavor transfer to amniotic fluid and breast milk and children's responses: a systematic review. Am J Clin Nutr. 2019;109(Supplement_1):1003S-26S.
36. Forestell CA. You Are What Your Parents Eat: Parental Influences on Early Flavor Preference Development. Nestle Nutr Inst Workshop Ser. 2020;95:78–87.
37. Mennella JA, Reiter AR, Daniels LM. Vegetable and fruit acceptance during infancy: impact of ontogeny, genetics, and early experiences. Adv Nutr. 2016;7(1):211S-S219.
38. Forestell CA. Flavor perception and preference development in human infants. Ann Nutr Metab. 2017;70(Suppl. 3):17–25.
39. Nicklaus S. The role of dietary experience in the development of eating behavior during the first years of life. Ann Nutr Metab. 2017;70(3):241–5.
40. Rohlfs DP. A new look at early exposure to the flavors of the available vegetables as foundational mechanism of vegetable consumption habits and recipes of vegetables-based dishes. Crit Rev Food Sci Nutr. 2021;61(5):855–66.
41. de Snoo K. Das trinkende Kind im Uterus. Gynecol Obstet Invest. 1937;105:88–97.
42. Liley AW. Disorders of amniotic fluid. In: Assali NS, editor. Pathophysiology of gestation: fetal placental disorder. New York, NY: Academic Press; 1972. p. 157–206.
43. Mennella JA, Beauchamp GK. Experience with a flavor in mother's milk modifies the infant's acceptance of flavored cereal. Dev Psychobiol. 1999;35(3):197–203.
44. Hausner H, Nicklaus S, Issanchou S, Mølgaard C, Møller P. Breastfeeding facilitates acceptance of a novel dietary flavour compound. e-SPEN. 2009;4(5):e231-e8.
45. Forestell CA, Mennella JA. Early determinants of fruit and vegetable acceptance. Pediatrics. 2007;120(6):1247–54.
46. Hausner H, Nicklaus S, Issanchou S, Molgaard C, Moller P. Breastfeeding facilitates acceptance of a novel dietary flavour compound. Clin Nutr. 2010;29(1):141–8.
47. Maier AS, Chabanet C, Schaal B, Leathwood PD, Issanchou SN. Breastfeeding and experience with variety early in weaning increase infants' acceptance of new foods for up to two months. Clin Nutr. 2008;27(6):849–57.
48. Mennella JA. Development of food preferences: lessons learned from longitudinal and experimental studies. Food Qual Pref. 2006;17(7–8):635–7.
49.● Wagner S, Issanchou S, Chabanet C, Lange C, Schaal B, Monnery-Patris S. Weanling infants prefer the odors of green vegetables, cheese, and fish when their mothers consumed these foods during pregnancy and/or lactation. Chem Senses. 2019;44(4):257–65. **This study provides a nice illustration of psychophysical methods used to understand odor preferences in young children and provides some evidence for associations between maternal perinatal diet and infant flavor preferences.**
50. Uwaezuoke SN, Eheh CI, Ndu IK, Iloh K, Udorah MI. Maternal diet during exclusive breastfeeding can predict food preferences in preschoolers: a cross-sectional study of mother-child dyads in Enugu, South-East Nigeria. Int J Child Health Nutr. 2017;6:70–9.
51. Hepper PG, Wells DL, Dornan JC, Lynch C. Long-term flavor recognition in humans with prenatal garlic experience. Devel Psychobio. 2013;55(5):568–74.
52. Liem DG, Bogers RP, Dagnelie PC, de Graaf C. Fruit consumption of boys (8–11 years) is related to preferences for sour taste. Appetite. 2006;46(1):93–6.
53. Kong KL, Gillman MW, Rifas-Shiman SL, Wen X. Mid-childhood fruit and vegetable consumption: the roles of early liking, early consumption, and maternal consumption. Appetite. 2016;105:306–11.
54. Yuan WL, Nicklaus S, Lioret S, Lange C, Forhan A, Heude B, et al. Early factors related to carbohydrate and fat intake at 8 and 12 months: results from the EDEN mother–child cohort. Euro J Clin Nutr. 2017;71(2):219–26.
55. Ashman AM, Collins CE, Hure AJ, Jensen M, Oldmeadow C. Maternal diet during early childhood, but not pregnancy, predicts diet quality and fruit and vegetable acceptance in offspring. Matern Child Nutr. 2016;12(3):579–90.
56. Bjerregaard AA, Halldorsson TI, Tetens I, Olsen SF. Mother's dietary quality during pregnancy and offspring's dietary quality in adolescence: follow-up from a national birth cohort study of 19,582 mother-offspring pairs. PLoS Med. 2019;16(9):e1002911.
57. Soldateli B, Vigo A, Giugliani ER. Effect of pattern and duration of breastfeeding on the consumption of fruits and vegetables among preschool children. PLoS One. 2016;11(2):e0148357.
58. Borkhoff CM, Dai DWH, Jairam JA, Wong PD, Cox KA, Maguire JL, et al. Breastfeeding to 12 mo and beyond: nutrition outcomes at 3 to 5 y of age. Am J Clin Nutr. 2018;108(2):354–62.
59. Vieira SA, De Almeida Fonseca PC, Andreoli CS, Hermsdorff HHM, Ribeiro AQ, Pereira PF, et al. Exclusive breast-feeding and sociodemographic characteristics are associated with dietary patterns in children aged 4–7 years. Public Health Nutr. 2019;22(8):1398–405.
60. Moss KM, Dobson AJ, Tooth L, Mishra GD. Associations between feeding practices in infancy and fruit and vegetable consumption in childhood. Br J Nutr. 2020;124(12):1320–8.
61. Weinfield NS, Borger C, Gola AA. Breastfeeding duration in a low-income sample is associated with child diet quality at age three. J Hum Lact. 2021;37(1):183–93.

62. Kheir F, Feeley N, Maximova K, Drapeau V, Henderson M, Van Hulst A. Breastfeeding duration in infancy and dietary intake in childhood and adolescence. Appetite. 2021;158:104999.
63. Hamulka J, Zielinska MA, Jeruszka-Bielak M, Górnicka M, Głąbska D, Guzek D, et al. Analysis of association between breastfeeding and vegetable or fruit intake in later childhood in a population-based observational study. Int J Environ Res Public Health. 2020;17(11):3755.
64. Fonseca PCDA, Ribeiro SAV, Andreoli CS, De Carvalho CA, Pessoa MC, De Novaes JF, et al. Association of exclusive breastfeeding duration with consumption of ultra-processed foods, fruit and vegetables in Brazilian children. Eur J Nutr. 2019;58(7):2887–94.
65. Spaniol AM, Da Costa THC, Bortolini GA, Gubert MB. Breastfeeding reduces ultra-processed foods and sweetened beverages consumption among children under two years old. BMC Public Health. 2020;20(1).
66. Yuan WL, Lange C, Schwartz C, Martin CK, Chabanet C, De Lauzon-Guillain B, et al. Infant dietary exposures to sweetness and fattiness increase during the first year of life and are associated with feeding practices. J Nutr. 2016;146(11):2334–42.
67. Bell LK, Jansen E, Mallan K, Magarey AM, Daniels L. Poor dietary patterns at 1–5 years of age are related to food neophobia and breastfeeding duration but not age of introduction to solids in a relatively advantaged sample. Eat Behav. 2018;31:28–34.
68. Nguyen AN, van Langeveld AWB, de Vries JHM, Ikram MA, de Graaf C, Mars M, et al. Dietary taste patterns in early childhood: the Generation R Study. Am J Clin Nutr. 2020.
69. Okubo H, Miyake Y, Sasaki S, Tanaka K, Hirota Y. Feeding practices in early life and later intake of fruit and vegetables among Japanese toddlers: the Osaka Maternal and Child Health Study. Public Health Nutr. 2016;19(4):650–7.
70.•• Beckerman JP, Slade E, Ventura AK. Maternal diet during lactation and breast-feeding practices have synergistic association with child diet at 6 years. Public Health Nutr. 2020;23(2):286–94. **Beckerman and colleagues were among the first to directly test whether the combination of longer breastfeeding durations and greater maternal fruit and vegetable intake during lactation predicts greater child fruit and vegetable intakes during infancy and childhood.**
71. Mourtakos SP, Tambalis KD, Panagiotakos DB, Antonogeorgos G, Arnaoutis G, Karteroliotis K, et al. Maternal lifestyle characteristics during pregnancy, and the risk of obesity in the offspring: a study of 5,125 children. BMC Pregnancy Childbirth. 2015;15:66.
72. Margerison-Zilko CE, Shrimali BP, Eskenazi B, Lahiff M, Lindquist AR, Abrams BF. Trimester of maternal gestational weight gain and offspring body weight at birth and age five. Matern Child Health J. 2012;16(6):1215–23.
73. Ensenauer R, Chmitorz A, Riedel C, Fenske N, Hauner H, Nennstiel-Ratzel U, et al. Effects of suboptimal or excessive gestational weight gain on childhood overweight and abdominal adiposity: results from a retrospective cohort study. Int J Obes (Lond). 2013;37(4):505–12.
74. Diesel JC, Eckhardt CL, Day NL, Brooks MM, Arslanian SA, Bodnar LM. Gestational weight gain and the risk of offspring obesity at 10 and 16 years: a prospective cohort study in low-income women. BJOG. 2015;122(10):1395–402.
75. Lawlor DA, Lichtenstein P, Fraser A, Langstrom N. Does maternal weight gain in pregnancy have long-term effects on offspring adiposity? A sibling study in a prospective cohort of 146,894 men from 136,050 families. Am J Clin Nutr. 2011;94(1):142–8.
76. Hinkle SN, Sharma AJ, Swan DW, Schieve LA, Ramakrishnan U, Stein AD. Excess gestational weight gain is associated with child adiposity among mothers with normal and overweight prepregnancy weight status. J Nutr. 2012;142(10):1851–8.
77. Shapiro AL, Kaar JL, Crume TL, Starling AP, Siega-Riz AM, Ringham BM, et al. Maternal diet quality in pregnancy and neonatal adiposity: the Healthy Start Study. Int J Obes (Lond). 2016;40(7):1056–62.
78. Oken E, Rifas-Shiman SL, Field AE, Frazier AL, Gillman MW. Maternal gestational weight gain and offspring weight in adolescence. Obstet Gynecol. 2008;112(5):999–1006.
79. Tahir MJ, Haapala JL, Foster LP, Duncan KM, Teague AM, Kharbanda EO, et al. Higher maternal diet quality during pregnancy and lactation is associated with lower infant weight-for-length, body fat percent, and fat mass in early postnatal life. Nutrients. 2019;11(3).
80. Grobler L, Visser M, Siegfried N. Healthy Life Trajectories Initiative: summary of the evidence base for pregnancy-related interventions to prevent overweight and obesity in children. Obes Rev. 2019;20(Suppl 1):18–30.
81. Patel N, Godfrey KM, Pasupathy D, Levin J, Flynn AC, Hayes L, et al. Infant adiposity following a randomised controlled trial of a behavioural intervention in obese pregnancy. Int J Obesity. 2017;41(7):1018–26.
82. Dalrymple KV, Tydeman FAS, Taylor PD, Flynn AC, O'Keeffe M, Briley AL, et al. Adiposity and cardiovascular outcomes in three-year-old children of participants in UPBEAT, an RCT of a complex intervention in pregnant women with obesity. Pediatr Obes. 2020:e12725.
83.•• Phelan S, Clifton RG, Haire-Joshu D, Redman LM, Van Horn L, Evans M, et al. One-year postpartum anthropometric outcomes in mothers and children in the LIFE-Moms lifestyle intervention clinical trials. Int J Obes (Lond). 2020;44(1):57–68. **The LIFE-Moms consortium of randomized clinical trials was the first to test a variety of lifestyle interventions with different dietary components during pregnancy and examined effects on maternal and child outcomes through 12 months postpartum.**
84. Van Horn L, Peaceman A, Kwasny M, Vincent E, Fought A, Josefson J, et al. Dietary approaches to stop hypertension diet and activity to limit gestational weight: maternal offspring metabolics family intervention trial, a technology enhanced randomized trial. Am J Prev Med. 2018;55(5):603–14.
85. Phelan S, Abrams B, Wing RR. Prenatal intervention with partial meal replacement improves micronutrient intake of pregnant women with obesity. Nutrients. 2019;11(5).
86. Vesco KK, Leo MC, Karanja N, Gillman MW, McEvoy CT, King JC, et al. One-year postpartum outcomes following a weight management intervention in pregnant women with obesity. Obesity (Silver Spring). 2016;24(10):2042–9.
87. Phelan S, Hart CN, Jelalian E, Munoz-Christian K, Alarcon N, McHugh A, et al. Effect of prenatal lifestyle intervention on maternal postpartum weight retention and child body mass index z-score at 36 months. Int J Obes (Lond). 2021.
88. Kolu P, Raitanen J, Puhkala J, Tuominen P, Husu P, Luoto R. Effectiveness and cost-effectiveness of a cluster-randomized prenatal lifestyle counseling trial: a seven-year follow-up. Plos One. 2016;11(12).
89. Redman LM, Phelan S. It is time to take preconception health seriously. Obesity (Silver Spring). 2016;24(2):279.
90. LeBlanc ES, Smith NX, Vesco KK, Paul IM, Stevens VJ. Weight loss prior to pregnancy and subsequent gestational weight gain: Prepare, a randomized clinical trial. Am J Obstet Gynecol. 2020.
91. Dhana K, Haines J, Liu G, Zhang C, Wang X, Field AE, et al. Association between maternal adherence to healthy lifestyle practices and risk of obesity in offspring: results from two prospective cohort studies of mother-child pairs in the United States. BMJ. 2018;362:k2486.
92. Ventura AK. Does breastfeeding shape food preferences? Links to obesity Ann Nutr Metab. 2017;70(Suppl 3):8–15.

93. Larsen JK, Bode L. Obesogenic programming effects during lactation: a narrative review and conceptual model focusing on underlying mechanisms and promising future research avenues. Nutrients. 2021;13(2):299.
94. Koletzko B, Godfrey KM, Poston L, Szajewska H, van Goudoever JB, de Waard M, et al. Nutrition during pregnancy, lactation and early childhood and its implications for maternal and long-term child health: the early nutrition project recommendations. Ann Nutr Metab. 2019;74(2):93–106.
95. Agricultural Research Service Community Nutrition Research Group. Results from USDA's 1994–96 Diet and Health Knowledge Survey: Table Set 19. U.S. Department of Agriculture; 2000.
96. Thompson AL. Intergenerational impact of maternal obesity and postnatal feeding practices on pediatric obesity. Nutr Rev. 2013;71:S55–61.
97. Birch LL, Doub AE. Learning to eat: birth to age 2 y. Am J Clin Nutr. 2014;99(3):723s-s728.
98. Savage JS, Fisher JO, Birch LL. Parental influence on eating behavior: conception to adolescence. J Law Med Ethics. 2007;35(1):22–34.
99. Hart C, Raynor H, Jelalian E, Drotar D. The association of maternal food intake and infants' and toddlers' food intake. Child Care Health Dev. 2010;36(3):396–403.
100. Phelan S, Hagobian T, Brannen A, Hatley KE, Schaffner A, Munoz-Christian K, et al. Effect of an Internet-based program on weight loss for low-income postpartum women: a randomized clinical trial. J Am Med Assoc. 2017;317(23):2381–91.
101. Phelan S, Hagobian TA, Ventura A, Brannen A, Erickson-Hatley K, Schaffner A, et al. 'Ripple' effect on infant zBMI trajectory of an internet-based weight loss program for low-income postpartum women. Pediatr Obes. 2019;14(1).
102. Arnold MJ, Sorensen D, Buelt A. Interventions for reducing childhood obesity. Am Fam Physician. 2020;101(7):394–6.
103.• Black MM. Toddler development and autonomy: baby-led weaning, neophobia, and responsive parenting. Nestle Nutr Inst Workshop Ser. 2020;95:1–11. **This paper provides an excellent review of developmental changes in young children's eating behaviors and food acceptance patterns, as well as the importance of responsive parent feeding practices and styles.**
104. Beck AL, Hoeft KS, Takayama JI, Barker JC. Beliefs and practices regarding solid food introduction among Latino parents in Northern California. Appetite. 2018;120:381–7.
105. Hinkle SN, Zhang C, Grantz KL, Sciscione A, Wing DA, Grobman WA, et al. Nutrition during pregnancy: findings from the National Institute of Child Health and Human Development (NICHD) Fetal Growth Studies-Singleton Cohort. Curr Dev Nutr. 2021;5(1):nzaa182.