Research Topics

Healthy eating and parenting messages to prevent obesity

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Healthy eating and parenting messages to prevent obesity

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Editorial: Healthy eating and parenting messages to prevent obesity

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Editorial on the Research Topic
Healthy eating and parenting messages to prevent obesity

National food and dietary guidelines translate science for public and professional audiences. Upstream, guidelines are established by scientific committees with the intent of informing the communications or messages of clinicians, educators, and marketers to parents, children, patients, and consumers downstream. Guidelines have historically addressed what and how much to eat, but messages about where, when, why, and how to eat or feed children have emerged in the current national guidelines. For example, the *Dietary Guidelines for Americans, 2020–2025* includes guidance for parents and caregivers of newborns that addresses developmental readiness for introducing solid foods, strategies for introducing complementary foods and beverages, and guidance for responsive feeding to support healthy eating patterns (1). Recognition that eating is influenced by habits, culture, and context is warranted to better support behavior change for health promotion and disease prevention.

This Research Topic brought together research from multiple countries about messages that address where, when, why, and how to eat or feed children with the intent of supporting healthy eating and preventing obesity. Ramuscak et al. observe improved parental awareness, knowledge, and opinions about the 2019 Canada's Food Guide compared to the earlier 2007 version. Use of the Food Guide by parents of young children remained persistently low from 2007 to 2019, but given the high recall of the plate model recommendation, the authors call for research that investigates whether practicing this recommendation translates to dietary changes. Also from North America, Shamah-Levy et al. evaluate data from six National Health and Nutrition Surveys in Mexico and report the obeso-protective effects of increased fruit and vegetable consumption among school-age children. They discuss cross-cutting environmental policies to promote the availability and consumption of sustainable and affordable foods to protect against overweight and obesity in children. Policy strategies aimed at reducing sugar-sweetened beverages remain an important topic in North America. In a qualitative study, Haynes-Maslow et al. observe that adolescents appreciate the long-term drawbacks of sugar-sweetened beverages but hold positive perceptions about consuming these beverages at social and special events. These findings suggest that messages focusing on short-term health consequences may be protective.

This Research Topic also yielded innovative approaches for understanding the high prevalence of child overweight and obesity. Reporting from the Arab countries, Habib-Mourd et al. describe a novel public–private partnership to advance healthy nutrition and physical activity among school-age children. Their framework offers a potentially sustainable, culturally tailored model that could be delivered at scale for primary prevention. Karssen et al. report on an app-based program to promote healthy parenting practices early in life. Promising growth outcomes were observed after 6 months among children with parents randomized to the app condition compared to children in the waitlist-control group. Nezami et al. also report on an mHealth intervention that engaged adults with overweight and obesity and their child. At the 6-month follow-up, they observed an inverse dose-response relationship between parent app use and the proportion of calories from fat and the overall collateral benefits between parent dietary changes and child intake.

Multiple papers investigated strategies that help to understand the association between parenting practices, home and family environment, and child factors. Papaioannou et al. advance science about parent feeding styles, dietary quality, and weight in Hispanic families with low household incomes. While most research has been cross-sectional, they report findings about the directionality of the influence with a prospective longitudinal study. Specifically, an authoritarian feeding style may offer protection in the self-regulatory processes around child appetitive traits. Eagleton et al. also report findings from a prospective longitudinal study in early life. They identify pressure-based feeding and the use of food to soothe as intervention targets to protect against infant food responsiveness. In another prospective study, Loth et al. report on the use of an ecological momentary assessment to evaluate practices among parents of preschool-aged children. Their findings underscore the need to understand how context influences parenting practices and the need to better support parents in response to stress and other factors. Finally, Larsen et al. conduct a systematic review related to parenting practices with a focused lens on families in a lower socioeconomic position. The structural and social factors that parents face warrant attention to promote healthy growth and development. Specifically, targeting structure-related food parenting practices that make healthy foods available and accessible should be regarded as a high priority to establish a more protective environment.

This Research Topic identifies research gaps, informs on the translation of evidence into practice, and may inform future policy guidance to better advance public health objectives related to healthy childhood weight.

Author contributions

LB-D and JS equally contributed to conceptualizing the Research Topic, reviewing manuscripts, and summarizing the collective work as an Editorial. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Maternal Feeding Styles and Child Appetitive Traits: Direction of Effects in Hispanic Families With Low Incomes

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Feeding styles of parents have been associated with dietary quality/intake and weight outcomes; however, much of the research to date has been cross sectional and the direction of influence unclear. This prospective longitudinal study evaluated the direction of effects between feeding styles and child appetitive traits over time in a sample of 129 Hispanic parent/child dyads that participated in a larger study. Data analyzed for the current study were collected when the children were 4–5 years old and again at ages 7–9 years. Parents (all mothers) reported on their feeding styles and children's appetitive traits using well-established questionnaires. Cross-lagged panel analyses were used to examine the direction of effects. Fully adjusted models revealed that a number of children's appetitive traits at baseline predicted later feeding styles. A bi-directional relationship was found between authoritarian feeding and satiety responsiveness such that higher satiety responsiveness was associated with authoritarian feeding and vice versa. Lower satiety responsiveness was associated with indulgent feeding, whereas higher food responsiveness was associated with authoritarian feeding. Results show preliminary evidence that children's appetitive traits may shape mothers' approach to child feeding. There is also preliminary support for the protective role of an authoritarian feeding style in the self-regulatory processes around child appetitive traits among this population of Hispanic families with low-income levels. These results warrant continued research given that other studies have shown beneficial outcomes for authoritarian feeding among ethnically diverse families with low incomes.

Keywords: Hispanic families, feeding styles, bi-directional effects, cross-lagged panel analysis, child appetitive traits

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INTRODUCTION

Parental feeding plays a major role in the development of child eating including food preferences, appetitive traits, and dietary quality/intake (1–6). Parental feeding influences what, when, and how much children eat and has been linked to the above mentioned child eating behaviors (7) as well as childhood obesity (2, 4). Parental feeding includes both goal oriented feeding practices such as restriction and pressure to eat as well as feeding styles, the broader, more general approach parents use to socialize their children around eating (8). The concept of feeding style includes the emotional climate created between parents and their children during eating events (8, 9). Feeding styles are thought to influence appetite self-regulation in children. Appetite self-regulation involves a wide range of trait-like behaviors that reflect biological bottom-up and cognitive top-down aspects of eating that are reflected in hunger and satiety responses (10). Appetite self-regulation shapes the quality of dietary intake and quantity of food eaten by children (i.e., portion sizes). Similar to general self-regulation in children, bottom-up processes are thought to involve biological drives toward food motivation and avoidance, whereas top-down processes are thought to involve cognitive appraisal (10).

Feeding styles have been consistently associated with child eating and weight (9). For example, the authoritative feeding style has been associated with lower intake of snack foods (11) and better diet quality of meals served to and consumed by children at dinnertime (12). In contrast, the indulgent feeding style has been associated with higher intake of energy dense snacks (11), lower intake of vegetables, dairy, and fruit (13), and larger portion sizes selected (14). Similarly, the uninvolved feeding style has been associated with less healthy outcomes such as lower child intake of fruit and vegetables (13). Overall, consistent evidence has shown that the indulgent feeding style is associated with more problematic child eating—more energy dense foods, greater child self-served portion sizes, and higher weight status across cross-sectional and longitudinal studies (9).

Despite the plethora of studies on feeding practices and styles, child food preferences, appetitive traits, and dietary quality/intake, and weight, many of these studies use cross-sectional designs prohibiting causal inferences and/or the examination of the direction of influence (i.e., parent, child, or both). Developmental scientists typically emphasize a bi-directional relationship between the parent and child (15); however, the common view of the feeding relationship is unidirectional, emphasizing parental behaviors directed toward the child. This perspective is problematic as it does not allow for child characteristics that may influence feeding interactions, such as mother's response to the highly food motivated child (16, 17). It is becoming increasingly apparent in the feeding literature that the parent-child relationship is likely reciprocal (18–22).

Only a handful of studies (n = 7) have evaluated bi-directional relationships of parental feeding and various child eating behaviors. Furthermore, all of those studies focused on goal-directed feeding practices. Specifically, five of these studies found bi-directional effects with feeding practices predicting child food responsiveness, emotional overeating, and eating large amounts of food and vice versa (18–22). In contrast, two studies found effects only from feeding practices to child appetitive traits, such as eating in the absence of hunger (23) and emotional overeating, food responsiveness, and enjoyment of food (24). For the most part, these studies targeted highly coercive practices (i.e., restriction, pressure to eat, food as a reward, and/or similar constructs) and a few structured practices (i.e., monitoring and family meals). For example, instrumental feeding (i.e., using food as a reward) was found to have a positive bi-directional association with child food responsiveness (18) and emotional overeating (18, 21). Monitoring and pressure to eat were found to have a negative bi-directional association with children eating large amounts of food (19). Monitoring also showed a negative bi-directional relationship with food refusal whereas pressure to eat showed a positive bi-directional relationship with the same construct (19).

Findings from these studies give rise to the possibility of a complex bi-directional relationship. However, only highly controlling feeding practices (e.g., restriction, pressure to eat, and using food as a reward) were targeted in these studies. The focus on goal-oriented behaviors may be too narrow when attempting to understand the complex mechanisms leading to obesity related health outcomes in children. Examining a more global approach to feeding may allow for the inclusion of aspects of the parent-child feeding relationship that are beyond the measurement of specific type feeding practices. Unfortunately, no studies to date have examined bi-directional effects using the feeding styles construct. Examining feeding styles is important as it represents a more consistent construct over time and across the various contexts that parent-child eating occasions occur (25).

Therefore, we used cross-lagged panel analyses to examine parent-reported feeding styles and child appetitive traits across two time periods (i.e., child ages 4–5 and 7–9), using longitudinal data from a previous study of how child appetitive traits develop among a Hispanic sample of families with low-income levels (26, 27). We included child appetitive traits that have shown consistent relationships with weight in previous studies (28). Specifically, satiety responsiveness has been negatively, and food responsiveness and emotional overeating have been positively related to child weight.

The aim of this study was to prospectively evaluate the direction of influence between feeding styles and child appetitive traits over a 3-year period in early childhood among a diverse sample of children with low-income backgrounds. In examining the influence from child appetitive traits (ages 4–5) to feeding styles (ages 7–9), we hypothesized that children who were satiety responsive (food avoidant) would have mothers who reported an authoritarian feeding style. In contrast, we predicted that children who were characterized by emotional overeating and food responsiveness (food approaching) would have mothers who reported an indulgent feeding style. In examining the influence from feeding to child appetitive traits, we predicted that mothers who exhibited an authoritative feeding style would have children who were more satiety responsive (ability to cease consumption in response to internal signals) as these mothers are more autonomy supportive. We predicted that mothers who exhibited an indulgent feeding style would have children who were more likely to be food approaching (emotional overeating and food responsive). **Figure 1** shows the hypothesized paths from feeding styles to child appetitive traits and vice versa in a conceptual model. Results from this study provide a broader view of the feeding and eating dynamics between parents and their children overtime by clarifying the directional influences of their interactions.

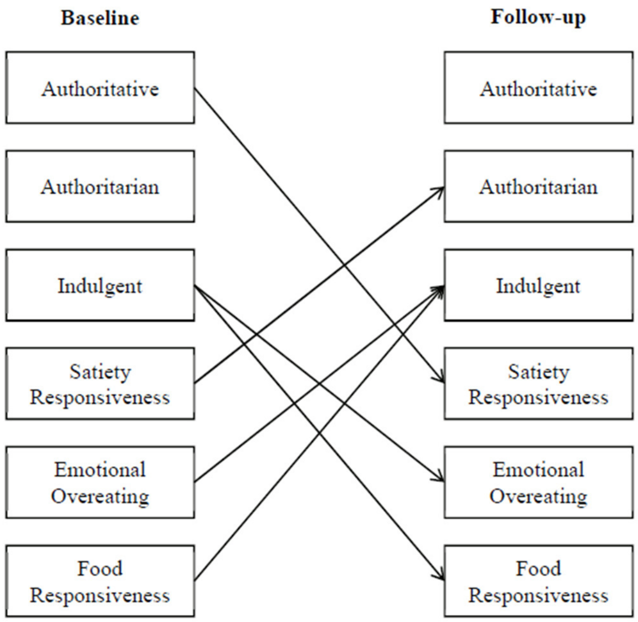

FIGURE 1 | Conceptual model depicting hypothesized paths.

TABLE 1 | Characteristics of the sample at baseline.

Characteristics	All participants, *M* (SD) or % (*n* = 129)
Parent gender—female	100.0
Child gender—female	53.5
Parent age, mean in years (SD)	31.55 (6.60)
Child age, mean in years (SD)	4.76 (0.46)
Education of parent	
Less than high school diploma	38.0
High school diploma or equivalent	24.0
Some college or more	38.0
Employment status, currently employed	20.9
Marital status	
Married	58.9
Never married	14.0
Widowed, separated, divorced	27.1
Parent immigrant status	
Born in the U.S.	17.8
Born in Mexico	63.5
Born in Central America	17.9
Born in Cuba	0.8
Child immigrant status	
Born in the U.S.	96.9
Child BMI categories	
Underweight (<5th percentile)	1.6
Healthy (5th to <85th percentile)	48.8
Overweight (85th to <95th percentile)	22.5
Obese ($\geq$95th percentile)	27.1

METHODS

Participants

Participants in the current study were 129 Hispanic parents and their children enrolled in Head Start who participated in a previous longitudinal study (n = 187) of how child appetitive traits develop in families with low-income levels (27, 29). All participating parents were mothers; thus, parents will be referred to as mothers hereafter. A convenience sample of mothers and their children were recruited from Head Start districts in a large urban city in the southern part of the United States beginning in 2011. Eligibility criteria were mothers self-identifying as Hispanic (either English or Spanish speaking) and their child attending Head Start (ages 4 or 5) at the time of recruitment. Exclusion criteria included mothers and/or children with extensive dietary restrictions (e.g., those with diabetes, food allergies, or on special diets) and children with developmental problems limiting their ability to perform study tasks (e.g., autism and significant developmental delays). If issues of eligibility arose, a pediatrician (co-investigator) reviewed the dietary restrictions and/or developmental delay diagnoses to determine participation in the study. The study was reviewed and approved by the Institutional Review Board at the Baylor College of Medicine (ethics approval number H-26796). The purpose of the study was explained to mothers in their language of choice (i.e., English or Spanish). Written consent for their participation as well as child verbal assent were obtained. Consenting procedures took place before study activities began at both baseline and the follow-up.

The original sample of 187 mother-child dyads were recruited at baseline for the larger longitudinal study (26). Approximately 18 months after baseline (M = 18.39, SD = 1.58), assessments were conducted on 144 dyads. Finally, ∼24 months after the follow-up (M = 23.6, SD = 6.54), assessments were conducted on 129 dyads. More information on recruitment and retention can be found in a previous publication (27). Data from the first follow-up were not included in the present study to reduce the number of analyses and because individual differences in child appetitive traits were relatively stable between baseline and the first follow-up, mean r = 0.53. Less stability was observed between baseline and the second follow-up (referred to as "follow-up" henceforth), mean r = 36. A total of 129 mothers and their children had data on all variables for analyses in the current study. Children's ages at baseline and the follow-up assessment were M = 4.76 (SD = 0.46) and M = 8.34 (SD = 0.71), respectively.

Presented in **Table 1** are the demographics on mothers whose data were analyzed for this study—a subsample of the 187 mother-child dyads. Mothers were an average of 31.55 years old (SD = 6.6), and most were homemakers (79.1%), married (58.9%), and either born in Mexico (63.5%) or Central America (17.9%). Mothers showed a range of educational status (ranging from 6th grade to beyond college graduate). About half of the children were female and about half had a healthy weight status (1.6% were in the underweight category). Twenty-two and one half percent were in the overweight category and 27.1% were in the obese category. Combined, these percentages are higher than the 30% of 2- to 5-year-old Hispanic children in the United States who are considered overweight or obese (30). We expected higher levels of children having overweight and obesity in our sample compared to those in the general population because our sample was urban with low incomes from the southern region of the United States. Moreover, our participants were toward the upper end of the 2- to 5-year-old age range; since the prevalence of overweight and obesity increases with age, we expected levels higher than average across our age range. No significant differences were found on demographic variables between the 129 mothers and children who had data at both baseline and follow-up and the initial sample of 187 mothers and children (**Table 1**). Participants in this study were not necessarily representative of the Hispanic population in the United States but may be representative of those in this geographical area.

Measures

Questionnaires used in the study were translated into Spanish using standardized procedures and have shown reliability and validity in Hispanic samples—Caregiver's Feeding Styles Questionnaire (8, 31, 32), and Children's Eating Behavior Questionnaire (33). Demographic information was obtained including birth dates (parent and child), ethnicity, race, gender, education, marital status, employment status, and immigrant status.

Caregiver's Feeding Styles Questionnaire

Mothers reported on their feeding style using the CFSQ (8), which is designed to assess feeding styles in families with low-income levels and has been used successfully with Hispanic families (3). Parents responded to 19 items using a 5-point response scale ranging from 1 = Never to 5 = Always. Dimensions of demandingness (i.e., how much parents encourage eating during eating episodes) and responsiveness (i.e., how parents encourage eating; the level of nurturance parents use in directing child eating) were calculated using seven child-centered items (e.g., asking questions, providing reasons, and allowing choice) and twelve parent-centered items (e.g., using food as a reward, hurrying the child, and spoon-feeding the child) (8). A cross-classification of high and low scores on these dimensions translates into four feeding styles: authoritative (high responsiveness, high demandingness), authoritarian (low responsiveness, high demandingness), indulgent (high responsiveness, low demandingness), and uninvolved (low responsiveness, low demandingness). Because children's eating becomes more autonomous with increasing age (and parental demands decrease), different median splits were used for demandingness at baseline and the follow-up (based on median scores for demandingness at each time point, 3.05 and 2.53, respectively). The corresponding medians for responsiveness, which did not change with age, were 1.19 and 1.22. A more detailed discussion of the scoring procedure can be found elsewhere (8). Evidence of test-retest reliability, internal consistency, convergent and predictive validity has been demonstrated (3). The CFSQ has been validated with direct observation of parent/child interactions during mealtimes (31). The CFSQ has been used successfully in studies of parents with children in elementary school (34–36) as well as with younger ages (8, 31). Coefficient alphas for child-centered and parent-centered items were 0.67 and 0.84, respectively.

Children's Eating Behavior Questionnaire

Mothers reported on their child's eating by completing the CEBQ which has established factor structure, test-retest reliability, and internal consistency (37). The CEBQ measures eight dimensions of eating including four subscales assessing food approach (food responsiveness, emotional overeating, enjoyment of food, desire to drink) and four subscales assessing food avoidance (satiety responsiveness, slowness in eating, emotional under-eating, and food fussiness) (37). To minimize the number of variables in the analyses, three subscales were used: two food approach subscales of food responsiveness (e.g., "My child is always asking for food") and emotional overeating (e.g., "My child eats more when worried"); and one food avoidant subscale of satiety responsiveness (e.g., "My child gets full before his/her meal is finished"). These subscales were chosen because they reflect individual differences in child appetitive traits and have been linked prospectively to parental feeding and/or child weight in previous studies (28) (see Section Data Analyses for further clarification). Coefficient alphas in the current sample were 0.80 for food responsiveness, 0.70 for emotional overeating, and 0.68 for satiety responsiveness.

Bi-Dimensional Acculturation Scale

The BAS was used to measure mothers' acculturation to the U.S. culture (38). It consists of three subscales: language use with 6 items (e.g., How often do you speak English?), language proficiency with 12 items (e.g., How well do you read in English?), and electronic media with 6 items (e.g., How often do you watch television programs in English?). As originally described by Marin and Gamba (38), the three subscales were combined to create a Spanish domain and an English domain, which had high internal consistency in the original study (alpha of 0.90 and 0.96, respectively). Cronbach's alphas were acceptable in this sample: Spanish and English domains (alpha of 0.92 and 0.97, respectively). Because there was very little variability in the Spanish domain score (almost 90% of the participants had a score of three or above on a scale of one to four), we used only the English domain score in the analyses.

Anthropometrics

Trained research staff took child height and weight measurements following a standard protocol (39). Children were measured twice with no shoes and wearing light clothing using a stadiometer (Seca model 214, Seca, China) and an electronic self-calibrating digital scale (Health-O-Meter model 752KL, Health O Meter, China). Measurements were recorded to the nearest 0.1 kg (weight) and 0.1 cm (height). Using the Centers for Disease Control and Prevention Reference Standards, age- and gender-specific Body Mass Index (BMI) standardized scores (BMI *z*-score) were calculated (40) and children were categorized as underweight (BMI $<$ 5th percentile), healthy weight (BMI $\geq$5th to $<$85th percentile), overweight (BMI $\geq$85th to $<$95th percentile), or obese (BMI $\geq$ 95th percentile).

TABLE 2 | Results of cross-lag panel analyses predicting follow-up variables from baseline variables (unstandardized B weights).

	Follow-up child appetitive traits			Follow-up parent feeding style		
Baseline predictor	**Satiety responsiveness**	**Emotional overeating**	**Food responsiveness**	**Authoritative feeding style**	**Authoritarian feeding style**	**Indulgent feeding style**
Satiety responsiveness	0.49***	0.12	0.18	0.02	0.11*	−0.14*
Emotional overeating	−0.26**	0.30**	−0.06	−0.06	−0.08	0.16
Food responsiveness	0.26***	0.03	0.47***	0.02	0.10*	−0.12
Authoritative feeding style	0.28	0.20	−0.02	0.19*	0.05	−0.12
Authoritarian feeding style	0.32*	0.12	−0.11	0.15	0.18	−0.20
Indulgent feeding style	0.23	0.18	−0.05	0.05	0.03	0.10
R^2	0.32	0.17	0.20	0.07	0.11	0.16

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

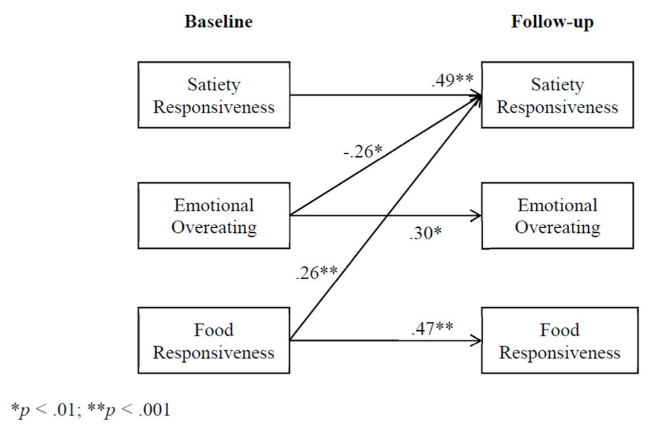

FIGURE 2 | Cross-lagged panel analysis: child appetitive traits to child appetitive traits (unstandardized B weights). *$p < 0.01$; **$p < 0.001$.

Data Analyses

Data were analyzed using AMOS (version 27) and $p < 0.05$ was used in all analyses. To address missing data for subscale scores, if 25% or less of the items on a given subscale were blank, the subscale score was calculated by computing the mean of the non-missing items. If more than 25% of the items were blank, the score on the given subscale was considered missing. The cross-lagged analysis was conducted using six primary variables at each time point and five controls (child gender, child BMI *z*-score at baseline, maternal education, maternal acculturation, and maternal BMI at baseline). The six primary variables were three dummy coded variables to represent the four feeding styles (with uninvolved feeding as the reference group) and the three child appetitive traits as measured by the satiety responsiveness, emotional overeating, and food responsiveness subscales of the CEBQ.

We chose authoritative, authoritarian, and indulgent feeding styles because of their consistent associations with child weight status (positively or negatively) in previous studies of general parenting or feeding styles (3). We chose appetitive traits that reflect individual differences in child appetite self-regulation. Specifically, satiety responsiveness is a measure of better appetite self-regulation, while food responsiveness and emotional overeating are measures of poorer appetite self-regulation. Other CEBQ subscales measure the construct less directly (i.e., slowness in eating, desire to drink, and enjoyment of food).

Model fit was determined by examining the chi square (n.s.), the CFI (≥0.95), and the RMSEA (<0.06) (41). Because feeding style (a single construct) was represented by three dummy coded variables, the errors for these variables were allowed to correlate. Unstandardized B weights are presented in **Table 2** and **Figures 2**, **3** because standardized regression weights with dichotomous dependent variables are hard to interpret. Full information maximum likelihood (FIML) was used to estimate missing values.

RESULTS

The results of the cross-lagged panel analyses are presented in **Table 2** and **Figures 2**, **3**. To achieve model fit, the error terms between emotional overeating and food responsiveness at follow-up were allowed to correlate, standardized $B = 0.67$, $p < 0.001$. The cross-lagged model showed excellent fit, $X^2_{(11)} = 12.35$, n.s., $CFI = 0.998$, $RMSEA = 0.026$. As shown by the significance ($p < 0.05$) of the unstandardized B weights in the table, only the authoritative feeding style was significantly stable over time; however, all three child appetitive trait variables were significantly stable. In addition to the stability findings, in two instances, child appetitive traits at baseline significantly predicted child appetitive traits at follow-up (**Figure 2**). Specifically, emotional overeating at baseline negatively predicted satiety responsiveness at follow-up, and food responsiveness at baseline positively predicted satiety responsiveness at follow-up. As shown in **Figure 3**, three "child direction of effects" associations were seen where child appetitive traits at baseline predicted parental feeding styles at follow-up: (1) satiety responsiveness

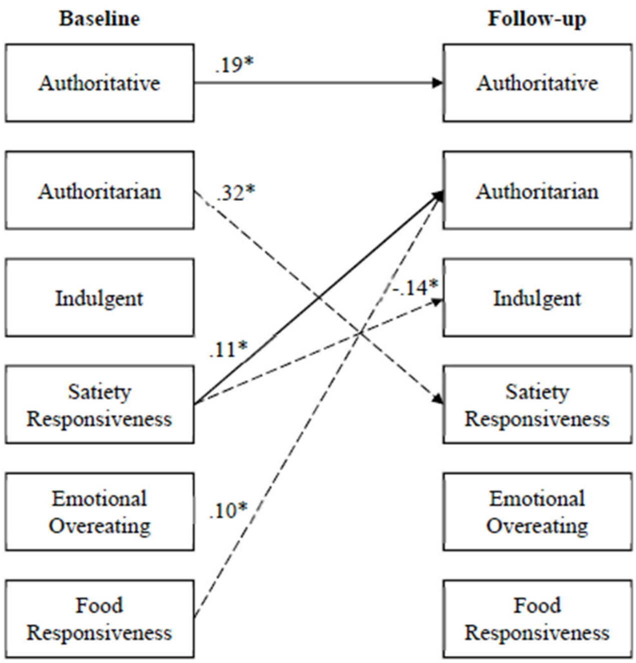

FIGURE 3 | Cross-lagged panel analysis: parental feeding styles to child appetitive traits and vice-versa (unstandardized B weights). Sold lines represent hypothesized effects; dotted lines represent effects not hypothesized. $^{*}p < 0.05$.

at baseline positively predicted authoritarian feeding at follow-up, (2) satiety responsiveness at baseline negatively predicted indulgent feeding at follow-up, and (3) food responsiveness at baseline positively predicted authoritarian feeding at follow-up. Only one "parent direction of effects" association was significant where feeding styles at baseline predicted child appetitive traits at follow-up: authoritarian feeding at baseline positively predicted satiety responsiveness at follow-up.

DISCUSSION

The current study examined the direction of influence between parent-reported feeding styles and child appetitive traits in a sample of Hispanic mothers from low-income backgrounds and their children. Only a few studies have found bi-directional associations between parental feeding and child outcomes (18–22); however, to our knowledge, this is the first examination of such associations between parental feeding styles and child appetitive traits over time. The results of this study provide initial evidence supporting the premise that children's appetitive traits influence how mothers parent their children around eating. These findings are in contrast to much of the current literature that views parent-child eating under the lens that child appetitive traits are in response to parental feeding directives—despite much of the literature being based on cross-sectional data. Specific to this study, of the six paths hypothesized in the analyses (three paths from feeding to appetitive traits and three from appetitive traits to feeding), only one path from feeding to appetitive traits was significant (from the authoritarian feeding style to satiety responsiveness). In contrast, three paths were significant from child appetitive traits to feeding (satiety responsiveness to authoritarian feeding, satiety responsiveness to indulgent feeding, and food responsiveness to authoritarian feeding).

As predicted, children who were higher in satiety responsiveness at baseline had mothers who were later categorized as authoritarian. Authoritarian feeding style and children who are satiety responsive. This was the only bi-directional relationship found in the study. Although our main findings suggest that the way parents approach feeding their children is guided by child eating characteristics (e.g., food responsive and satiety responsive), this study also provides evidence of a bi-directional relationship where parenting/feeding shapes children's eating behavior in some instances. Additionally, it has been suggested that parenting characterized by high demandingness and warmth but low in autonomy granting, in general, may be a protective behavior in Hispanic families with low-income levels (45). These families may perceive highly demanding parenting behaviors as being involved rather than intrusive. Our findings are consistent with the premise of authoritarian parenting in the feeding context as a protective behavior in Hispanic families (46) which may extend to child appetite self-regulation.

The potentially protective functions of control in the feeding literature mirror findings in general parenting such that types of control associated with negative child outcomes in non-Hispanic samples often show weaker, non-significant, or positive relationships in Hispanic samples (42, 43). Because Hispanic mothers sometimes show high levels of control, certain controlling interactions may not have a negative impact because they are a way through which Hispanic mothers show involvement and caring with their children (44). This interpretation is consistent with the concept of protective parenting in Hispanic families—characterized by high demandingness, high responsiveness, and low autonomy granting (45). High levels of control exhibited by Hispanic parents, rooted in the values of familism and respect for authority, may support healthful child development (45) and be protective against childhood obesity as well.

It was hypothesized that children who were characterized by food approach traits of emotional overeating and food responsiveness would have mothers who reported an indulgent feeding style. Results from this study did not support these hypotheses. This lack of association is surprising as previous studies have shown children who exhibit food approach type behaviors have parents who exhibit higher levels of emotional feeding and use food as a reward (24, 46, 47). It was expected that indulgent feeders may reinforce early emotional eating by not setting limits and letting children eat as much as they want. The previous studies cited above were conducted with predominantly white samples. There is a need for qualitative studies of indulgent feeding among Hispanics with low incomes to better understand the construct within this cultural group. Along the same lines, lower satiety responsiveness at baseline was associated with indulgent feeding at follow-up. Given that satiety responsiveness is considered a food avoidant trait among children, it is not surprising that lower food avoidance was associated with a feeding style characterized by not setting limits and allowing excess food intake.

The finding of higher food responsiveness and authoritarian feeding is supported by previous research showing associations between coercive control type practices (i.e., restriction; threats and bribes) and food approach traits such as food responsiveness (20–22, 24). Authoritarian feeders have been observed to exhibit coercive control practices through direct observation of family meals (8, 31). It makes sense that children who exhibit higher food approach traits would have parents who are authoritarian demonstrating coercive control type practices in an effort to restrict children's intake.

Regarding the stability of the child appetitive traits in the current study, as expected, child appetitive traits (as measured by the CEBQ) were somewhat stable overtime from child ages 4–5 to 7–9 years. This finding is in line with literature showing that child appetitive traits may have a genetic component and that children are born with tendencies toward food avoidance or food approach (48–51). This finding has been demonstrated in several other studies (19, 20, 52–54).

Findings should be considered in light of the limitations. Only one ethnic group was included in the study. Furthermore, with the exception of child height and weight that was objectively measured, parental feeding styles and child appetitive traits were assessed using parent-reported questionnaires. Social desirability has been implicated as a bias in parent-report of their own behavior and that of others (e.g., their children) (55). However, one strength is the wide use of the chosen questionnaires in the overall feeding literature (9, 28) and the validation of the CFSQ with direct observation (31). Another strength is the use of a longitudinal design which allowed for examination of the direction of influence of feeding styles and child appetitive traits overtime from preschool to middle childhood within the Hispanic cultural group.

In conclusion, based on the findings of this study, there is preliminary evidence showing that children's appetitive traits may shape mothers' approach to child feeding. Furthermore, there is also preliminary support for the protective role of an authoritarian feeding style in child self-regulatory processes around eating among this population of Hispanic families. Satiety responsiveness which was prospectively associated with authoritarian feeding over time has been consistently linked to lower child weight across multiple previous studies (28). Results need to be replicated in a larger sample and understood within the parenting culture of this ethnic group. Specifically, additional studies are needed to understand the potential protective role of the highly demanding authoritarian feeding style on more healthful child outcomes among Hispanic and other ethnically diverse families with low incomes.

Overall, most studies examining parental feeding and child appetitive traits are cross-sectional and those that are longitudinal assume that the direction of effects is from the parent to the child. Findings from this longitudinal study support future efforts examining how child characteristics may shape the parent-child dynamic as it relates to childhood obesity. Targeting this dynamic in childhood obesity prevention programs will foster better child outcomes and support public health efforts to reduce obesity among children.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Institutional Review Board at the Baylor College of Medicine. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

SH and TP conceived the research question and designed the study. MP, TP, and SH drafted the manuscript. SH oversaw all data collection. TP ran the data analyses. TO'C and JF assisted with the design of the study and provided comments on the manuscript. NM coordinated all data collection and provided comments on the manuscript. All authors were involved in writing the paper and had final approval of the submitted and published versions.

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Comparing the perceptions and opinions of the 2007 and 2019 Canada's food guides among parents of young children

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Background: The Canada's Food Guide (CFG) is recognized as the most prominent authoritative guideline for healthy eating in Canada. In 2019, Health Canada released the latest iteration of the CFG with substantial changes to its messaging and format from the previous 2007 CFG.

Objective: This study compared the awareness, use, knowledge, and opinions of the 2007 and 2019 CFGs among parents with children aged 18 months to 5 years who are participants in a family-based intervention trial, the Guelph Family Health Study.

Methods: The sample consisted of 327 parents (59% women) who responded to questions about the 2007 CFG and 177 parents (60% women) who responded to questions about the 2019 CFG. Parents' awareness and knowledge of the 2007 and 2019 CFGs were compared using Pearson's Chi-Square, while parents' opinions of the two CFGs were compared using Wilcoxon Rank-Sum tests. To describe and provide context about how parents used the 2007 and 2019 CFG descriptive analysis was used. To analyze the open-answer comments parents provided for the 2007 and 2019 CFGs thematic coding was used.

Results: Awareness of the 2007 and 2019 CFGs was high with 94.5 and 90.4% of parents reported having heard about the 2007 and 2019 CFGs, respectively. Knowledge of the plate proportion recommendations in the 2019 CFG was significantly higher than knowledge of the recommended number of servings in the 2007 CFG with 93.4% of parents identifying the Vegetable and Fruit Plate Proportions in the 2019 CFG. Parents identified that the 2019 CFG was a helpful and trustworthy resource, and that it was easier to follow and understand, and more representative of their culture and traditional foods than the 2007 CFG.

Conclusion: Our results suggest that parents' knowledge of the 2019 CFG recommendations was higher than for the 2007 CFG recommendations. Parents also had more positive opinions about the 2019 CFG as compared to the 2007 CFG. Future research is needed to explore whether these higher levels knowledge of the 2019 CFG recommendation translate to healthier eating patterns among Canadian families.

KEYWORDS

food-based dietary guidelines, Canada's Food Guide, perceptions, opinions, parents

Introduction

The World Health Organization (WHO) describes healthy eating as the cornerstone to good health and nutrition (1). Consuming a healthy diet rich in plant-based foods such as vegetables, fruit, whole grains, legumes, lentils, and nuts and seeds, throughout the life course can support healthy growth and development, prevent malnutrition, and reduce the risk of developing chronic diseases like obesity, type 2 diabetes, and hypertension (2). However, there is evidence to suggest that many Canadian children and adults' diets are poor and fail to meet dietary recommendations (3, 4).

Of the many factors that can influence one's diet, nutrition knowledge has been described as the most amenable to change and has been the driver of numerous nutrition interventions and health campaigns (5, 6). Existing research suggests a weak, positive relationship between knowledge and consumption of healthy foods and dietary patterns among both adults and children (5, 7–17). These results underscore the idea that nutrition knowledge may be a necessary, although not sufficient, factor in facilitating and supporting healthy eating. Thus, it is vital that credible, evidence-based education, tools, and resources be available and accessible to inform Canadians' eating patterns and behaviors.

The Canada's Food Guide (CFG) is a knowledge translation tool that translates nutrient requirements and scientific evidence into practical tools and resources to promote healthy eating to Canadians ages 2 years and older. The latest CFG was released in January 2019 and replaced the previous CFG released in 2007 (18). Despite the CFG being recognized as an authoritative guideline for healthy eating, existing research on the 2007 CFG suggests that many Canadians do not use the Food Guide and may not understand it. Although awareness of the 2007 CFG has consistently been reported as being high (19–22), studies suggest that most Canadians do not use the Food Guide as a primary source for healthy eating and nutrition information (20, 21, 23). Furthermore, evidence on the 2007 CFG suggests that many Canadians have a difficult time recalling the four food groups and correctly identifying the number of recommended servings for these food groups based on their age and sex (21, 23–25). A study of the 2007 CFG found that only 43% of adults were able to correctly list all four food groups and <1% were able to recall all food group recommended servings (23).

The 2007 CFG has also received mixed reviews and criticism from researchers, health professionals, and the general public. Specifically, the 2007 CFG has been criticized for being "obesogenic" as it promotes excess calorie consumption and does not take into consideration calories consumed from "other" foods; lacking representation of cultural and traditional foods; being difficult to follow and apply into daily life; and, being highly influenced by the food and beverage industry (19, 22, 26–29).

The 2019 CFG was significantly revised. The rainbow model used in the 2007 CFG was replaced with a plate model. The number of food groups decreased from four to three, with the 2019 CFG amalgamating the Milk & Alternatives and Meat & Alternatives food groups into one Protein Foods food group. The specific recommendations for number of servings per food group based on individual's age and sex in the 2007 CFG was replaced with one universal recommendation for all Canadians based on the proportions of a plate (30, 31). Health Canada also revised the policy process to develop the 2019 CFG by including new rules for advisory committee membership, new and regular evidence review cycles, as well as new stakeholder consultation processes which precluded direct consultation with industry stakeholder and regulated interactions with stakeholders by publishing any communication between Health Canada and stakeholders online (30–33).

Little is known about Canadians' opinions on the 2019 CFG. While a recent survey (34), social media analysis (35), and qualitative study (36) have explored Canadians' opinions of the 2019 CFG, no studies have directly compared opinions of the 2019 to the 2007 CFG. Thus, the objective of this study was to build upon previous research of awareness, use, knowledge, and opinions of CFGs by comparing the perceptions and opinions of the 2007 and 2019 CFGs among parents of young children. Given that parents play a key role in determining their children's eating patterns as well as their own (7), understanding parents' knowledge and perception of food-based dietary guidelines is critical to informing family-based nutrition interventions and policies.

Materials and methods

Study design

A multiple cross-sectional study was conducted using data from the Guelph Family Health Study (GFHS), a randomized controlled trial of a family-based intervention focused on improving sleep, screen time, physical activity, and family meal routines among families with preschool aged children. Families were eligible to participate in the GFHS if they had at least one child between 18 months to 5 years, lived in the Guelph area in Ontario, Canada area and had one parent who could respond to questionnaires in English. The data used in this multiple cross-sectional study were drawn from parents who completed a Baseline or 6-month online survey via Qualtrics, between January 2018 to March 2020. From January 2018 to March 2019, the GFHS Baseline and 6-month surveys included questions regarding the 2007 CFG. To reflect Health Canada's revisions to the Food Guide in January 2019, the GFHS surveys were updated in March 2019 to ask parents about their perceptions and opinions of the 2019 CFG. Depending on the timing of families' enrolment in the GFHS, some parents only answered questions about the 2007 CFG (n = 250) or the 2019 CFG (n = 100), while others (n = 77) completed questions about both the 2007 and 2019 CFGs at separate time points. For this study, we examined all parents who completed questions on either the 2007 Food Guide, the 2019 Food Guide, or both the 2007 and 2019 Food Guides, which yielded a total analytic sample of 504 responses. This study was approved by the University of Guelph Research Ethics Board (REB #17-07-003).

Measures

The survey questions used for this study were drawn from the GFHS Baseline and 6-month survey and were composed of 5 sections: demographics, awareness of CFGs (2 questions), use of CFGs (2 questions), knowledge of CFGs recommendations (11 questions), and opinions of the CFGs (12 questions).

Awareness

Parents' awareness of the 2007 CFG was assessed with the question: "Have you heard about Canada's Food Guide?" The questions regarding the 2019 CFG were preceded by a preamble that stated "In **January 2019**, Health Canada released a **new** Canada's Food Guide. Below are some questions to assess your use and opinion about the **new** Canada's Food Guide." The question to assess parents' awareness of the 2019 CFG asked: "Have you heard about the **new** Canada's Food Guide?" Responses were compared between the two Food Guides and used as a dichotomous measure (yes, I have heard about the Food Guide, or no, I have not heard about the Food Guide).

Use

Parents' use of the 2007 and 2019 CFGs was assessed with the question: "What do you use/have you used Canada's Food Guide for?" The question regarding the 2019 CFG asked specifically about using "the **new** Canada's Food Guide." Parents were provided with several answers and were able to select one or more answers that applied to their family: "to guide my food choices"; "to help me ensure I am feeding my child(ren) healthy foods"; "to plan healthy meals for myself and my family"; "to help me understand portion sizes"; "to help make sure my family and I are getting enough vitamins, minerals, and other nutrients"; "to reduce my risk of chronic diseases such as cancer, diabetes, heart disease"; "to help maintain healthy weights for myself and family"; "to guide my food purchases"; "to help me understand the nutrition facts label"; "to help me limit unhealthy fats, such as saturated fat"; "to help me maintain optimal health and wellness"; "to find healthy recipes; to help me limit salt"; "to help me limit sugar"; "to help me increase plant-based protein"; "to help me limit animal-based protein"; "to help me contribute to the sustainability of the planet"; and, "others: please specify." Parents' responses to use of CFGs was analyzed using descriptive analysis to provide context to how parents may have used the 2007 and 2019 CFGs.

Knowledge

Parents' knowledge of the 2007 and 2019 CFGs were assessed by examining whether parents could correctly identify the recommended number food guide servings for the 2007 CFG and food group proportions for the 2019 CFG. Parents were asked separate questions to assess their knowledge of recommendations for children (2-3 years) and adults (19 to 50 years old, based on parents' reported sex). Responses for parents' knowledge of the 2007 and 2019 CFGs' food group servings and proportions were assessed using a rubric matrix, and answers were coded as correct or incorrect. The total score of parents' knowledge for CFG 2007 food group servings and 2019 proportions for adults and children was calculated by summing the number of correct answers for each food group. Each correct answer was coded as 1 while incorrect answers, "I don't know," "I am not comfortable answering this question," or blank answers were coded as 0.

Opinions

Using a five point-Likert scale (1 being strongly disagree and 5 being strongly agree), parents' opinions of the 2007 and 2019 CFGs were assessed by asking parents to rank how strongly they agreed or disagreed with the following statements: "Canada's Food Guide is a helpful resource for planning a healthy diet"; "I trust the information provided in Canada's Food Guide"; "I find Canada's Food Guide difficult to understand"; "I find Canada's Food Guide easy to follow"; "I find it difficult to feed my children according to Canada's Food Guide"; and, "Canada's Food Guide is representative of my culture and our traditional foods." As with the previous questions, the questions regarding the 2019 CFG asked specifically about using "the **new** Canada's Food Guide." Responses for parents' opinions of the 2007 and 2019 CFG were compared with each statement and used as ordinal measures.

Furthermore, parents were asked to share any other thoughts regarding CFG. These answers were thematically coded to determine common themes among parents' opinions of the 2007 and 2019 CFG; participants provided 126 comments about the 2007 CFG and 47 comments about the 2019 CFG.

Data analysis

Statistical analysis was conducted using R Statistical Software. To compare the awareness, use, knowledge, and opinions of the 2007 and 2019 CFGs, we compared responses from all parents who completed the questions regarding the 2007 CFG (n = 327) and all parents who completed the 2019 CFG questions (n = 177) using the following statistical analyses: Pearson's Chi-square for categorical data (e.g., awareness response, knowledge of each CFG food groups serving sizes/plate proportions for adults and children) and Wilcoxon Rank-Sum test for ordinal data (e.g., opinion responses). Descriptive analysis was used to compare and provide context about how parents used the 2007 and 2019 CFG. Thematic coding was used to analyze the responses parent provided to the open-ended questions asking parents to share any additional opinions they may have had about the 2007 and 2019 CFG.

To examine whether participants responses differed by intervention status, we stratified participants based on whether they were randomized into the intervention or control group, and used Pearson's Chi-square and Wilcoxon Rank-Sum tests to compare if any significant differences were observed among awareness, knowledge, and opinions of the 2007 and 2019 CFG. No significant differences were found between the intervention and control groups except for a single item asking whether the 2007 Canada's Food Guide is representative of my culture and our traditional foods (intervention group M = 3.43, control group M = 3.15, p = 0.003). Given the lack of substantive differences in responses between participants randomized to intervention and control, we present the unstratified results.

Results

Descriptive data

A total of 327 parents and 177 parents answered questions regarding the 2007 and 2019 CFG, respectively. The average age of parents who provided responses regarding the 2007 and 2019 CFGs were 35.8 and 36.6 years, respectively. In both samples, most participants were white, married, highly educated (university education or more), and had relatively high annual household income ($100,000+; Table 1).

TABLE 1 Characteristics of the parents who responded to questions about the 2007 CFG (n = 327) and the 2019 CFG (n = 177).

Variables	2007 n = 327 (%)	2019 n = 177 (%)
Gender		
Female	195 (59.63)	107 (60.45)
Male	132 (40.37)	68 (38.42)
Gender queer/gender non-conforming	0 (0)	2 (1.13)
Age, years, Mean (SD)	35.82 (4.61)	36.59 (4.97)
Ethnicity		
White	278 (85.01)	141 (79.66)
Non-White[a]	44 (13.45)	34 (19.20)
Explicitly did not disclose	5 (1.53)	2 (1.13)
Marital status		
Married	275 (84.35)	144 (81.35)
Not married, but living with partner	42 (12.88)	21 (11.86)
Single/Separated/Divorced	9 (2.77)	8 (4.50)
Annual household income, Canadian $		
<$49,999	30 (9.80)	22 (13.25)
$50,000–$99,999	123 (40.19)	38 (22.89)
$100,000–$149,999	84 (27.45)	63 (37.95)
>$150,000	69 (22.55)	43 (25.90)
Level of education		
Some university education or less	97 (29.66)	52 (29.37)
University graduate or more	230 (70.33)	125 (70.62)

[a]Non-White ethnicity included South Asian (e.g., East Indian, Pakistani, Sri Lankan, etc.), Chinese, Korean, Japanese, Southeast Asian, Black, West Asian, Latin American, and mixed ethnicity.

Awareness and use

Overall, parents had a high level of awareness of both the 2007 and 2019 CFGs with 94.5% of parents reported having heard of the 2007 CFG, while 90.4% of parents reported having heard of the 2019 CFG. Between the two Food Guides, no significant difference was observed in awareness of the 2007 and 2019 CFGs (p = 0.12). Of the parents who were aware of the 2007 and 2019 CFGs and reported using the guides (2007 = 31.39%, 2019 = 51.98%), the top reasons for using both guides were "To help ensure I am feeding my child(ren) healthy meals" and "To guide my food choices" (data not shown).

Knowledge

Parents' knowledge of the 2019 CFG plate proportion recommendations was higher than their knowledge of the 2007 CFG recommended number of servings. This difference in parents' knowledge was found for both recommendations for adults (19 to 50 years old, based on parents' reported sex) and children (age 2–3 years; Figures 1, 2).

Opinions

Compared to the 2007 CFG, we found significantly higher mean opinion scores for the 2019 CFG for items assessing

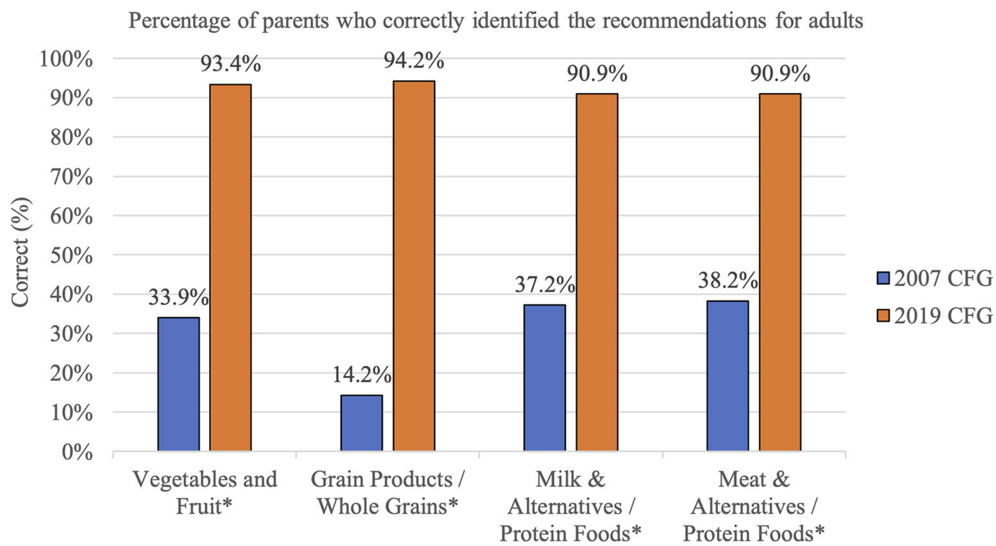

FIGURE 1
Knowledge of adult CFG food groups serving size (2007) and proportion (2019) recommendations among parents from the GFHS. *Asterisks indicates a statistically significant difference, $p < 0.05$.

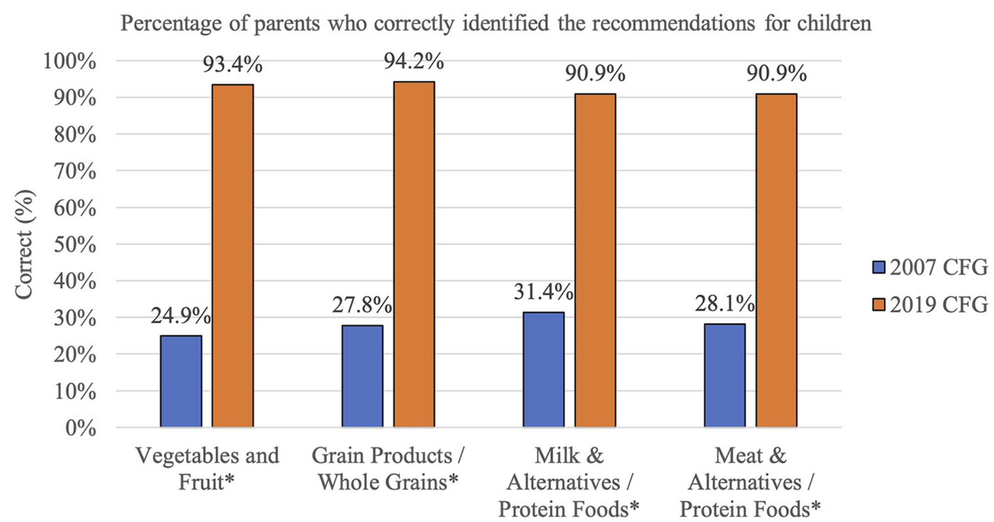

FIGURE 2
Knowledge of children CFG food groups serving size (2007) and proportion (2019) recommendations among parents from the GFHS. *Asterisks indicates a statistically significant difference, $p < 0.05$.

whether: (1) the CFG is a helpful resource for planning a healthy diet, (2) parents trust the information provided in the CFG, (3) the Food Guide is easy to follow, and (4) the Food Guide is representative of parents' culture and traditional foods. Compared to the 2007 CFG, mean scores for the 2019 CFG were lower for items assessing if parents find the CFG difficult to understand or if they find it difficult to feed children according to the Food Guide recommendations (Table 2).

Themes from open-ended question on the 2007 and 2019 CFG

Common themes that emerged from the open-ended questions included trust of the information provided in the Food Guides, ability to follow and use the Food Guide recommendations, lack of familiarity and use of Food Guide recommendations, and placement of dairy products in the Food Guides.

TABLE 2 Parents' opinions of the 2007 and 2019 CFGs.

Opinion	2007 CFG $n = 304^a$	2019 CFG $n = 119^a$			
	M	*M*	*Z*	*p-value*	*Effect size*
Canada's Food Guide is a helpful resource for planning a healthy diet.	3.25	3.78	−5.09	<0.001	0.25
I trust the information provided in Canada's Food Guide.	3.20	4.00	−8.00	<0.001	0.39
I find Canada's Food Guide difficult to understand.	2.31	2.09	−2.33	<0.05	0.12
I find Canada's Food Guide easy to follow.	3.50	3.89	−4.52	<0.001	0.22
I find it difficult to feed my children according to Canada's Food Guide.	2.95	2.44	−5.16	<0.001	0.25
Canada's Food Guide is representative of my culture and our traditional foods.	3.28	3.61	−3.25	<0.001	0.16

1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, 5 = Strongly Agree.
[a]Numbers differ slightly due to missing data in the opinion section.

Trust of information provided in the food guides

Parents described feelings of distrust with the 2007 CFG, citing industry influence as a major concern: "We find the food company sponsorship in the Canada's Food Guide a conflict of interest, and [it] damages credibility." Similarly, another parent shared: "I don't pay much attention to [Canada's Food Guide] because my impression is that it's highly influenced by industry lobbying." Conversely, the 2019 CFG was met with praises and acknowledgment that the foundation of the 2019 CFG was based on current evidence-based information, as one parent wrote: "It is great that they've renewed the Food Guide to better reflect what current research is saying and not just bending to what the heavily subsidized sectors (meat and dairy) want. I'm glad that they've emphasized reducing salt, sugar, and saturated fat, and [focused] on plant-based proteins."

Ability to follow and use the food guide recommendations

Regarding comments about the 2007 CFG, parents often reported challenges of conceptualizing and applying the 2007 CFG serving size recommendations: "It is too complicated to remember how many servings of what type and what size each individual member of the family is supposed to aim for." Similar challenges were also acknowledged by another parent, who wrote: "With all the food that goes unfinished on my child's plate, it's often difficult to track whether portion recommendations are being rigidly met. But we try to keep the ratios balanced throughout the day (2x dairy to meat, 2x produce to dairy, etc.)."

Parents found that the 2019 CFG is easier to follow and more inclusive, as several parents reported: "The proportions of the plate are much easier to understand than portion sizes on the previous food guide…It's visually pleasing," and "It seems simpler and easier to follow. I'm a vegetarian so it seems more inclusive." Parents also reported the complementary recipes and resources helped to further their understanding of the 2019 CFG, as one parent described: "It's very user friendly. Easy to read, easy to understand. Great photos to enhance topics. Great recipes and resources."

Lack of familiarity and use of food guide recommendations

For both the 2007 and 2019 Food Guides, many parents noted being aware of CFG, however, were not familiar with the specific recommendations. With the 2007 CFG, some parents wrote, "I know of the guide, but I do not know its content" and "I recognize that I think about it in abstract [but] not in details." Similar comments were also written about the 2019 CFG, as one parent described: "I briefly looked at it when it came out but honestly haven't used it or referenced back to it at all." Although parents wrote that they were not familiar with the 2019 CFG recommendations, some reported that they still had positive perceptions of the new Food Guide: "I don't recall specifics, but my impression of it was positive," and "I haven't consulted [the new Food Guide] as I generally think we eat a balanced diet. But I like how it includes things about the food experiences (i.e., eat with others) and the reality of life (i.e., not everyone can cook from scratch all the time, so when at a restaurant, try to make healthier choices)."

While many parents described not consulting the Food Guides, several parents reported "loosely" using the Food Guide recommendations to feed their families: "I don't look at the Guide on a regular basis to plan meals or 'rate' my family's meals against the serving suggestions included in the Guide; however, I use the principles included in it to guide what my family eats." Another parent wrote: "I haven't looked at an updated Canada's Food Guide. I would say that I roughly try to make sure we have multiple food groups per meal, including fruit and vegetables at every meal. We don't worry too much about portion sizes for healthy foods – we try to go by hunger/feel."

Placement of dairy and dairy products in the food guides

With the 2007 CFG, the Milk & Alternatives food group was often questioned by parents, with some writing: "Too much value placed on milk" and "There [is] a lot of [information] about dairy…not being great for us so I'm curious about [the food group] being on the guide so prominently." Parents also expressed concerns about family members with milk allergies or lactose intolerance, and not being able to meet the Food Guide recommendations: "…with a 13-month-old with a severe dairy allergy – I find it hard to find milk alternatives that meet the needs to fill that void. Actually, I find it impossible to meet that need."

One of the most discussed revisions in the 2019 CFG was the amalgamation of the 2007 CFG Milk & Alternatives and Meat & Alternatives food groups into a Proteins Foods food group. Most parents welcomed the change, with many parents supporting the deemphasis of the Milk & Alternatives food group: "It is about time milk was not considered something everyone MUST have," and "I like the combining of dairy into protein. It is how I already think of it – e.g., I kind of think of the protein food group as a group that includes foods that are high(er) in fat and a source of protein."

Although most parents agreed that combining the 2007 Food Guide Milk & Alternatives and Meat & Alternatives food groups into one Protein Foods food group in the 2019 CFG was a good idea, some parents expressed concerns about the perceived omission of dairy foods and the potential for inadequate nutrient intake: "I worry about the messages [the Food Guide] sends about calcium consumption (people interpreting it that 'dairy' is not necessary)." Another parent wrote: "I am concerned that dairy was only listed in protein…I think the new Food Guide should have pointed out that dairy is a good source of protein, and that it should not be cut out in favor of other protein because it is so important for calcium." One parent also expressed concerns about their child's daycare setting using the new Food Guide recommendations and the influence this may have on their child's diet: "I have concerns that my child's day care…is using the new protein category to take away healthy fats and proteins (such as milk) and provide more plant-based alternatives. The categories are too broad and I'm concerned that they will not provide adequate nutrition for my child."

Discussion

This is the first study to compare the knowledge, perceptions, and opinions of the 2007 and 2019 CFGs. Our results revealed that parents had high awareness of both the 2007 and 2019 Food Guides, significantly greater knowledge of the 2019 CFG recommendations, and more positive opinions of the 2019 CFG compared to the 2007 CFG. The exploration of parents' perceptions and opinions of both the 2007 and 2019 CFG is useful to inform our understanding of what parents think and value of food-based dietary guidelines. This understanding is especially important considering that parents' nutrition knowledge and opinions not only influence their own diet and healthy eating habits, but also the growth and development of their young children (7). The results of this study have the potential to advance the thinking about future CFG revisions and inform implementation and knowledge translation strategies for CFG and food-based dietary guidelines in other countries.

The high awareness of the CFGs is consistent with existing research that suggest awareness of CFG to be as high as 80–90% (20, 21, 23, 24, 34). Despite the high level of awareness among participants, studies have found that the use of CFG is low, with Slater and Mudryj's study reporting that only 8.7% of participants had consulted the 2007 Food Guide in the last 6 months (21). Similar findings were noted in our study's quantitative and open-ended responses regarding the 2007 and 2019 CFGs with many parents identifying that they had heard or were aware of the Food Guides, but were not using it to guide their food choices. This observation is not surprising, as participants from Slater and Mudryj's study ranked CFG as the fifth cited source for healthy eating information while participants from Charlebois and colleagues study ranked CFG as the sixth cited source (21, 34). Of the resources consulted for healthy eating information before the Food Guide, participants noted family and friends, general research, TV programs, and social media (21, 34). Research has suggested that consumers value targeted information that is easily accessible, interactive, dynamic, and tailored to their specific needs (37). Given the breadth and complexity of competing healthy eating and nutrition information available, efforts should be put toward creating accessible and tailored healthy eating information, and educating Canadians on how to decipher credible information.

This study also examined parents' understanding of CFG recommendations for adults and children by comparing whether parents could correctly identify the number of Food Guide servings for each food group (Vegetables and Fruit, Grain Products, Milk & Alternatives, and Meat & Alternatives) in the 2007 CFG and the correct plate proportions for each food group (Vegetables and Fruit, Whole Grains, and Protein Foods) in the 2019 CFG. Our study revealed a significant difference among all food groups with parents being able to correctly identify the 2019 plate proportions 91 to 94% of the time. Conversely, only 14 to 38% of parents were able to correctly identify the 2007 CFG food group serving recommendations for adults, with a slightly higher percentage (25 to 31%) of parents correctly identifying 2007 CFG serving recommendations for children. Similar findings about low knowledge of 2007 CFG recommendations have been observed in previous research (21, 23, 24). In Vanderlee and colleagues' study, only 1% of participants could correctly recall the number of servings for all four food groups (23). The low knowledge of the 2007 CFG recommendations are not surprising, as studies examining food guide recommended servings and serving sizes have revealed that they are difficult to conceptualize and apply (22, 36, 38–40).

Across the world, plate models are the second most popular national food-based dietary guideline graphic after the pyramid (41). However, limited research has been conducted to assess the plate model's effectiveness in communicating guidelines. Of the research that has been conducted, the results have suggested that the plate model, which typically includes guidelines for recommended servings of the food groups included on the plate, does not seem to be more effective in communicating healthy eating information compared to other formats like a pyramid or rainbow (42–44). However, research has noted that the plate model is well liked by participants for its visual appeal and modern look (41, 42). It has been suggested that the appeal of a plate model is that it promotes wholeness and a realistic perception of meal planning (41). Unlike hierarchical models, like a pyramid or rainbow, which convey numbers, rankings, and a disjointed, singular view of foods in food groups, the size of each proportion within the plate format dictates their importance to the whole and may resonate with individuals who consume their meals from plates (41). Given this rationale, and the significant increase in parents' ability to recall the 2019 Food Guide guidelines as compared to the food group serving recommendation in the 2007 CFG, future research should explore whether the 2019 CFG plate model translates into improved dietary intake.

Significant differences were observed in the opinions of parents regarding the 2007 and 2019 CFG, with more favorable opinions observed with the 2019 CFG. This finding is consistent with a 2019 survey of Canadian adults, which found that most participants agreed or strongly agreed that the 2019 Food Guide reflected their views and understanding of healthy eating; provided realistic and practical advice; was flexible to meet their dietary preference; was based on scientific evidence and best practices; and could influence food related behaviors (34).

In our study, significantly more parents agreed that they trusted the information in the 2019 CFG as compared to the 2007 CFG. Similar results were observed in the open-answer feedback, where parents cited concerns about the food and beverage industry's involvement in the development of the 2007 Food Guide, whereas parents identified that the 2019 CFG as evidence-based and provided scientifically sound information. These opinions were also noted in a qualitative study among Southwestern Ontario parents, with some parents viewing the 2019 CFG as focusing less on industry interests than previous food guides and acknowledging Health Canada's efforts in creating an evidence-based Food Guide (36). The significant change in opinions of CFG's trustworthy information could be the result of the deliberate effort of Health Canada to work toward more transparent reporting on the CFG development process (30–33). In a study conducted by Weldon and Parkhurst that compared the 2019 CFG to the principles of good governance, it was found that the 2019 Food Guide's development process met 21 out of the 28 measurable indictors of good governance (33). To compare, the authors found that only 6 of the 28 indicators were met by the 2007 CFG (33). Overall, Weldon and Parkhurst concluded that legitimizing good governance like stewardship, transparency, and contestability through the institutionalization of evidentiary processes can help in maintaining public trust of CFG's healthy eating information, which may have significant ramifications for implementing and achieving dietary outcomes (33). To further understand the impact of Health Canada's revised evidence review process for dietary guidance, future research should explore the relationship between Canadians' trust and adherence and use of CFG's healthy eating guidelines.

Parents had conflicting opinions regarding the amalgamation of the 2007 CFG Milk & Alternative and Meat & Alternative food groups into a single Protein Foods food group in the 2019 CFG. Although some parents supported the de-emphasis of the Milk & Alternatives food group in the 2019 Food Guide, some parents expressed concerns about the perceived omission of dairy products and the potential of inadequate intake of nutrients like calcium. Similar results have been shown in previous qualitative studies with Canadian parents (36, 45). A 2022 qualitative study with Canadian parents found that parents expressed concern as to whether dairy and dairy products fit on the 2019 Food Guide, if dairy was still considered "healthy," and how the perceived omission of dairy would affect their child's growth and development (36). Dairy and dairy products are a good source of nutrients like protein, calcium, vitamin D, phosphorus, and riboflavin, and can positively contribute to children's bone growth and height gain (46, 47). However, evidence from the Canadian Community Health Survey suggest that consumption of fluid milk is declining among all age groups in Canada, and incidences of vitamin D deficiency among Canadian children and adolescents are increasing (3, 48). Researchers have suggested that the decline in dairy intake, and subsequently the rise in calcium and vitamin D deficiency, may be further compounded by not highlighting milk and milk alternatives in the 2019 Food Guide (49). To better understand the impact of amalgamating the 2007 CFG Milk & Alternative and Meat & Alternative food groups, future studies should continue to monitor the intake of dairy and dairy products and calcium and vitamin D intake among Canadians. These results can help inform public health initiatives and educational programs to support correct interpretation of the 2019 CFG, i.e., that dairy products are included on the guide.

Despite our study's strengths, including being the first to compare the perceptions and opinions between two Food Guides, it also has several limitations. Firstly, our study's sample was predominantly homogenous with most participants identifying as white, highly educated, and from households with high annual income >$100,000. Thus, our results may not be generalizable to parents from ethnically diverse backgrounds or low-income households. Future research should examine the perceptions and opinions of CFG from Canadians with diverse socioeconomic and cultural backgrounds by using targeted partner-led recruitment strategies that engage community partners and champions who work with low-income and various cultural communities and by using selective sampling techniques, like quota sampling (50). A second limitation of this study was the timing of the GFHS surveys. Parents were asked about the 2007 CFG from January 2018 to January 2019, nearly 11 to 12 years after the 2007 CFG was initially released. It is unclear whether the timing of the survey played a significant role in participants' recall, knowledge, and opinions of the 2007 CFG's recommendations compared to the 2019 CFG's recommendations. It should also be considered that at the time of updating the GFHS survey with the new 2019 CFG, widespread media coverage of the 2019 CFG was present, with traditional media outlets and social media platforms frequently reporting on the updated recommendations, and interviewing nutrition and health professionals on their perspectives and opinions. It is unclear how often participants were exposed to these frequent media messages, and whether they had a significant influence in shaping parents' awareness, use, knowledge, and opinions of the 2019 CFG.

Our study results have implications for future policies and knowledge translation efforts regarding food-based dietary guidelines. Our results suggest that parents value the emphasis of current scientific evidence in developing the 2019 CFG and appear to have improved trust in healthy eating guidelines when industry involvement is regulated. Thus, to continue with public trust, Health Canada and other public health agencies should continue to implement transparent processes that safeguard the credibility of healthy eating guidelines. Second, parents acknowledged that the plate model was easier to follow, and that the complementary resources and recipes aided in their understanding of the Food Guide guidelines. Therefore, future Food Guide revisions should consider knowledge translation strategies that support the practical application of the Food Guide recommendations, and more specifically, that these strategies are culturally and contextually appropriate. Lastly, parents conflicting opinions on the amalgamation of the 2007 CFG Milk & Alternative and Meat & Alternative food groups, and confusion on where dairy and dairy products fit in the 2019 CFG may indicate that a knowledge gap exists among parents about the 2019 CFG Protein Foods food group. Future Food Guide revisions should consider providing clearer messages on the importance of consuming a variety of protein-rich foods, including dairy, and provide more guidance on the consumption of milk and milk alternatives for families with young children.

Overall, our study found that parents in the GFHS had a high level of awareness of both the 2007 and 2019 CFGs, greater knowledge of 2019 CFG plate proportion recommendations, and more positive opinions of the 2019 CFG compared to the 2007 CFG. Specifically, parents felt that the new Food Guide was a helpful and trustworthy resource, easier to follow and understand, and representative of their culture and traditional foods. Future studies examining Canadians' perceptions and opinions of CFG should be conducted among more culturally and socioeconomically diverse samples to allow for more generalizable results. Future research should also investigate whether awareness and knowledge of the 2019 CFG is associated with improved adherence to the 2019 CFG plate proportions and key healthy eating guidance.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by University of Guelph Research Ethics Board (REB #17-07-003). The patients/participants provided their written informed consent to participate in this study.

Author contributions

JH, DM, AD, and LF: conception and design of the research. AR and AS: statistical analysis. JH and DM: obtained funding. AR: writing of the manuscript. All authors were involved in the interpretation of the data, critical revision of the manuscript, and also read and approved the final draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.944648/full#supplementary-material

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Childhood obesity in Mexico: Influencing factors and prevention strategies

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Background: Overweight and obesity in school-age children, in Mexico as in other countries around the world, is a rapidly increasing public health problem within recent years, with important consequences for the future health of the population. Various national strategies at the individual and community level have been established to prevent these conditions, but none have yet succeeded.

Objective: To describe factors which influence overweight and obesity in school-age children five to 11 years old in Mexico, and national strategies for the prevention and management of these conditions.

Methods: The data herein is derived from six National Health and Nutrition Surveys in Mexico: 2006, 2012, 2016, 2018, 2020, and 2021. They include a total of 45,216 school-age children with complete anthropometric data (weight/height) distributed over 84 pseudo-panels defined by age, wellbeing condition class (WCC), gender, and type of locality of residence. The indicators calculated were overweight and obesity by body mass index according to World Health Organization guidelines. Predictors are food consumption indicators in five groups.

Results: The prevalence of overweight and obesity showed a positive linear trend ($p < 0.001$), with average annual increases of 0.41%. Increases in fruit consumption reduced the prevalence of these conditions by 6.6% ($p = 0.01$) and vegetable consumption reduced this by 8.3%.

Conclusions: Overweight and obesity in school-age children is a growing problem with serious repercussions for future life. New strategies are needed which focus on involving food systems, which translates to healthy and sustainable diets.

KEYWORDS
overweight, obesity, body mass index, prevention strategies, Mexico

Introduction

In Mexico, overweight and obesity has been recognized as a public health problem. This is thanks to the National Nutrition Surveys of 1988 and 1999 and the first National Nutrition and Health Survey (ENSANUT for its Spanish acronym) in 2006, which recorded significant increases in the prevalence of these conditions in women and children (1). In school-age children, the prevalence of overweight and obesity was 34.8% in 2006, 34.4% in 2012, 33.4% in 2016, 35.6% in 2018, 38.2% in 2020, and up to 37.3% in the year 2021 (2–4).

Over time, public policies have been established to address population health and nutrition problems. The principal programs created were *Prospera* (previously *Oportunidades*, then *Progresa*), the social milk supply program *Liconsa*, and the school lunch program (*Desayunos Escolares*). However, their objectives were historically based in achieving food access for the most vulnerable groups, and they were not designed from their beginnings to address the growing epidemic of overweight and obesity in Mexico (5).

Given the large burden that overweight and obesity can represent to health systems, the Organization for Economic Cooperation and Development (OECD) countries are expected to allocate 5.4% of their total health budget to treating conditions derived from obesity: 311 billion USD purchasing power equivalent per year. Obesity in school-age children has been associate with poorer academic performance (13%) and in later life stages it may have implications for human capital and socioeconomic level (6). In 2010, the Ministry of Health of Mexico developed and implemented the National Agreement for Nutritional Health (ANSA for its Spanish acronym), which promoted the development of healthy life skills (7). From the ANSA were born the General Guidelines for the Sale and Distribution of Prepared and Processed Food and Drinks in Schools within the National Educational System, with the goal to establish technical nutritional criteria to regulate the preparation, sale, and distribution of prepared and processed food and drinks appropriate for healthy eating within the public and private schools of the National Educational System (8). Later, in the year 2013, the Ministry of Health of Mexico implemented the National Strategy for the Prevention and Management of Overweight, Obesity and Diabetes, which aimed to slow the growing prevalence of overweight and obesity, as well as chronic diseases such as type two diabetes (9).

Furthermore, given that sugar-sweetened beverages are well understood as a casual factor of overweight and obesity, the year 2014 saw the implementation of a tax of one Mexican peso per liter on beverages with added sugars, as well as on food items with an energy content ≥275 calories per 100 g (10). In 2020, implementation began of the frontal warning label on packaged food items, as well as restrictions on the use of characters used on food packages to target marketing at children (11).

The present article describes factors influencing overweight and obesity in school-age children from 5 to 11 years of age in Mexico between the years 2006 and 2021, and national strategies for the prevention of these conditions.

Methods

We analyzed the information from ENSANUT surveys applied in 2006, 2012, 2016, 2018-19, 2020, and 2021. ENSANUTs have a probabilistic, stratified design by conglomerates; details on ENSANUT sampling procedures have been published previously (12) and ENSANUT databases and questionnaires may be retrieved in the webpage https://ensanut.insp.mx/ (13). For the present analysis, the population of interest was all children from 5 to 11 years of age selected in each year of the survey. The sample size in each survey was:14,990 school-age children in 2006; 16,351 in 2012; 3,179 in 2016; 6,183 in 2018–19, 1,944 in 2020, and 2,569 in 2021.

Variables

Nutritional status

All participants were weighed and measured by staff trained in internationally standardized methods (14, 15). Weight was measured with a SECA brand electronic scale produced in Germany, and height was measured with a SECA brand wall stadiometer produced in Germany. Using the tools previously mentioned, Z-score of body mass index (BMI) was calculated ($BMI = kg/m^2$) by age and sex. Using the standard references of the World Health Organization (WHO) (16), overweight (OW) was defined as a Z-score $> +1$ and up to $+2$ standard deviations, while obesity (OB) was defined as $> +2$ and up to $+5.5$ standard deviations.

Diet

Using information from a semi-quantitative food consumption frequency questionnaire, we classified food items in the following groups: **fruits** (peach/nectarine, strawberry, guava, jicama, lime, mango, apple/pear, cantaloupe/watermelon, orange/tangerine, papaya, pineapple, banana, grapefruit, grapes), **vegetables** (avocado, broccoli/cauliflower, zucchini, onion-for example in salads, street snacks or fast foods–chayote, green chili, dried chili, cabbage, green beans, corn, leafy greens, tomato, lettuce, cactus, cucumber, frozen vegetables such as peas, carrot, broccoli, cauliflower, or green beans, canned vegetables such as peas, carrots, mushrooms, and green beans and carrot), **plain water**, **snack foods**, **sweets and desserts** [chocolate, dairy-based or imitation desserts, candy (hard candies, lollipops), chili-coated candies, fried items (all types, including Japanese-style peanuts), candied or dried fruits, ice cream and dairy-based popsicles, water-based popsicles and shaved ice, fruits stored in nectar, gelatin, flan, marshmallow lollipops, microwave or movie popcorn (all types except caramel-covered), cake, pie], and **sugar-sweetened beverages** [natural fruit water with sugar added, corn-based *atole* with water, commercial flavored drinks with sugar, coffee with sugar added and with or without milk, natural juices with sugar added, commercial fruit nectars or pulp with sugar added, soda, tea with sugar added, dairy-based drink with lactobacillus, corn-based *atole* with milk, milk with added sugar or chocolate, prepared flavored milk (chocolate or other), drinkable whole milk yogurt with fruit, natural drinkable whole milk yogurt]. Consumers were defined as those school-age children who reported consumption of the food group of interest at least 3 days a week, in a quantity of at least 10 g. In the case of fruit, vegetables, and plain water, consumers were defined as those who consumed at least 10 grams seven days a week. Furthermore, derived from a database of nutritional composition (17, 18), we estimated the consumption of total energy and fiber per day per child.

Age

We classified age in years completed.

Sex

We classified sex as masculine or feminine.

Residence locality type

We classified localities with <2,500 inhabitants as rural (R), and those with ≥2,500 inhabitants as urban (U).

Wellbeing condition index

We constructed an index of wellbeing conditions based on housing characteristics and household goods and services using principal component analysis. The first component accumulated approximately 50% of the variance across all surveys. The WBI was classified in categories (WCC) using distribution tertiles as cut-off points: low, medium, and high.

Statistical analysis

From the series of six ENSANUT surveys, which are independent transversal samples, we created a temporary follow-up framework with grouped data in pseudo-panel (19, 20), using the variables age, sex, wellbeing level, and residence locality type (rural or urban). For each pseudo-panel group, we calculated prevalence of overweight and obesity, prevalence of consumption of each food groups, averages of consumption of recommended and not recommended food groups, and averages of consumption of total energy and fiber for each temporary follow-up group. We constructed a longitudinal model using pseudo-panel data, through a mixed model with estimation of random effects for maximum probability. The model allowed establishment of a lineal trend in the prevalence of obesity as a function of time (survey), consumption of fruits, vegetables, snack foods, and sugar-sweetened beverages. Age group, sex, wellbeing level, and residency locality type were used as adjustment variables.

Results

Table 1 shows the distribution of the main characteristics of the study population by survey year. The distribution by sex has been homogenous across all years, at 50% of each sex. Over 70% of participants have resided in urban localities, and in four of the six surveys the predominant wellbeing level was classified as low.

The prevalence of OW and OB, by survey years, and the percentages of consume of each food group are presented in Table 2. OW was primarily observed in the first survey years of 2006 (20.3%) and 2012 (20.0%), and in later years leveled at around 18.0%. On the other hand, OB prevalence was lesser in 2006 (14.7%) and shows a sustained increase over the following survey years until reaching nearly 20.0% in 2021. Across all survey years, average consumption of the food groups sugar-sweetened beverages and snack foods was notably greater than consumption of fruits and vegetables.

The longitudinal model of pseudo-panel data (Table 3) showed a positive lineal trend in the prevalence of OW and OB ($p > 0.001$), with average annual increases of 0.41%. We observed that an increase in the proportion of consumers of reduced prevalence of OW and OB by 6.6% ($p = 0.01$), while an increase in vegetable consumers contributed a reduction of 8.3%. Snack foods, sweets and desserts, and sugar-sweetened beverages were not statistically significant contributors in the model ($p = 0.112$ and 0.098, respectively), but seem to show weak associations. Of the adjustment variables, we observed that each year of age completed by participants was associated with an average increase of 2.8% in the prevalence of OB. Girls, as compared to boys, showed a 4.2% lower prevalence of OW and OB ($p < 0.001$), and a lower prevalence of these outcomes by 2.8% was shown for all those residing in rural zones. On the other hand, participants with a medium and high level of wellbeing showed an increased prevalence of obesity prevalence, of 6.6 and 12.9%, respectively ($p < 0.001$ for both).

Discussion

The findings of our study show that overweight and obesity in the school-age population, both on the Mexican and international stage, is a growing problem across the last several decades. These outcomes are associated with a greater percentage of consumers of food and drinks with high energy

TABLE 1 Descriptive characteristics of the study population.

Variable	2006				2012				2016				2018				2020				2021			
	n	N (thousands)	Percent	95% CI	*n*	N (thousands)	Percent	95% CI	*n*	N (thousands)	Percent	95% CI	*n*	N (thousands)	Percent	95% CI	*n*	N (thousands)	Percent	95% CI	*n*	N (thousands)	Percent	95% CI
Age																								
5	1,956	2,219.8	14.1	(13.14, 15.2)	2,232	2,250.5	13.7	(12.86, 14.56)	464	2,234.9	14.2	(12.23, 16.33)	857	1,397.5	12.9	(11.62, 14.26)	280	1,907.3	12.4	(10.79, 14.22)	365	2,118.3	13.5	(11.88, 15.33)
6	1,976	2,139.4	13.6	(12.69, 14.62)	2,343	2,290.9	13.9	(13.15, 14.75)	451	2,120.9	13.4	(11.76, 15.3)	903	1,448.7	13.4	(12.21, 14.6)	352	2,367.1	15.39	(13.86, 17.06)	394	2,170.3	13.9	(12.49, 15.33)
7	1,964	1,944.0	12.4	(11.62, 13.18)	2,438	2,331.6	14.2	(13.43, 14.96)	472	2,363.8	15.0	(12.11, 18.36)	964	1,553.9	14.3	(13.07, 15.68)	335	2,262.9	14.71	(12.99, 16.63)	375	2,128.0	13.6	(11.89, 15.46)
8	2,170	2,142.1	13.6	(12.85, 14.48)	2,489	2,381.8	14.5	(13.66, 15.35)	527	2,464.6	15.6	(13.62, 17.82)	984	1,635.8	15.1	(13.8, 16.46)	331	2,160.7	14.05	(12.5, 15.75)	375	2,102.7	13.4	(11.73, 15.31)
9	2,283	2,425.3	15.5	(14.48, 16.47)	2,505	2,330.5	14.2	(13.39, 14.99)	454	2,344.8	14.9	(12.32, 17.8)	951	1,661.9	15.3	(13.8, 16.97)	344	2,258.5	14.69	(13.01, 16.53)	418	2,329.0	14.9	(13.35, 16.52)
10	2,353	2,450.6	15.6	(14.75, 16.5)	2,095	2,265.5	13.8	(12.97, 14.63)	414	2,176.6	13.8	(11.53, 16.4)	769	1,605.8	14.8	(13.3, 16.46)	140	2,038.5	13.25	(11.15, 15.69)	331	2,523.8	16.1	(14.11, 18.32)
11	2,288	2,380.1	15.2	(14.3, 16.06)	2,249	2,593.4	15.8	(14.95, 16.63)	397	2,086.1	13.2	(11.28, 15.41)	755	1,542.3	14.2	(12.8, 15.77)	162	2,384.8	15.51	(13.33, 17.96)	311	2,300.2	14.7	(12.65, 16.97)
Sex																								
Female	7,503	7,888.8	50.2	(48.5, 51.01)	8,156	8,116.7	49.4	(49.47, 51.81)	1,591	7,760.3	49.1	(47.82, 53.89)	3,138	5,450.5	50.3	(47.78, 51.71)	941	7,573.0	49.2	(47.89, 53.63)	1,283	7,547.9	48.2	(48.97, 54.69)
Male	7,487	7,812.5	49.8	(48.99, 51.5)	8,195	8,327.4	50.6	(48.19, 50.53)	1,588	8,031.4	50.9	(46.11, 52.18)	3,045	5,395.2	49.8	(48.29, 52.22)	1,003	7,806.8	50.8	(46.37, 52.11)	1,286	8,124.4	51.8	(45.31, 51.03)
Area																								
Urban	10,070	11,299.4	72.0	(69.71, 74.11)	10,126	12,262.9	74.6	(73.47, 75.64)	1,368	11,392.0	72.1	(68.09, 75.86)	3,862	7,847.1	72.4	(70.68, 73.96)	1,400	11,272.5	73.3	(70.18, 76.19)	1,838	11,668.7	74.5	(71.92, 76.84)
Rural	4,920	4,402.0	28.0	(25.89, 30.29)	6,225	4,181.3	25.4	(24.36, 26.53)	1,811	4,399.6	27.9	(24.14, 31.91)	2,321	2,998.7	27.7	(26.04, 29.32)	544	4,107.3	26.7	(23.81, 29.82)	731	4,003.5	25.6	(23.16, 28.08)
WCC																								
Low	6,280	6,325.3	40.3	(38.15, 42.46)	6,303	5,233.3	31.8	(30.27, 33.42)	1,227	3,923.2	24.8	(21.38, 28.67)	2,534	4,157.2	38.3	(36.26, 40.44)	789	6,119.2	39.8	(36.08, 43.61)	984	5,765.5	36.8	(33.85, 39.82)
Medium	5,246	5,205.1	33.2	(31.49, 34.85)	5,592	5,502.6	33.5	(32.08, 34.88)	1,132	5,200.5	32.9	(29.61, 36.43)	2,155	3,731.1	34.4	(32.31, 36.56)	610	4,720.7	30.7	(27.87, 33.67)	899	5,234.4	33.4	(30, 36.98)
High	3,464	4,171.0	26.6	(24.69, 28.52)	4,456	5,708.3	34.7	(33.02, 36.45)	820	6,668.0	42.2	(37.3, 47.31)	1,494	2,957.5	27.3	(25.3, 29.33)	545	4,539.9	29.5	(26.61, 32.6)	686	4,672.4	29.8	(26.89, 32.91)

ENSANUT 2006, 2012, 2016, 2018-19, 2020, and 2021. Mexico.

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TABLE 2 Prevalence of nutritional conditions (A) proportion of consumer of food groups and intake of total energy and fiber (B), total energy and fiber for each temporary follow-up group.

Ensanut	Normal (%)				Overweight (%)				Obesity (%)			
	n	*N*	Prevalence	95% CI	*n*	*N*	Prevalence	95% CI	*n*	*N*	Prevalence	95% CI
A												
2006	9,588	10,204,938	65.0	(63.45, 66.5)	3,056	3,187,226	20.3	(19.16, 21.49)	2,346	2,309,197	14.7	(13.64, 15.85)
2012	10,709	10,734,574	65.3	(64.08, 66.46)	3,189	3,286,670	20.0	(18.97, 21.05)	2,453	2,422,889	14.7	(13.83, 15.69)
2016	2,197	10,464,529	66.3	(62.09, 70.2)	551	2,891,763	18.3	(15.45, 21.58)	431	2,435,344	15.4	(12.55, 18.81)
2018	3,955	6,985,674	64.4	(62.26, 66.5)	1,209	1,969,226	18.2	(16.68, 19.73)	1,019	1,890,871	17.4	(15.83,19.16)
2020	1,205	9,500,278	61.8	(58.89, 64.57)	388	3,038,218	19.8	(17.71, 21.97)	351	2,841,299	18.5	(16.41, 20.74)
2021	1,577	9,791,124	62.5	(59.51, 65.35)	510	2,923,987	18.7	(16.7, 20.78)	482	2,957,168	18.9	(16.86, 21.05)
Total	29,231	57,681,117	64.2	(63.11, 65.29)	8,903	17,297,090	19.3	(18.45, 20.08)	7,082	14,856,768	16.5	(15.73, 17.38)

Ensanut	Fruits (%)		Vegetables (%)		Snacks, sweets, and desserts (%)		Sweetened beverages (%)		Plain water (%)		Fiber consumption (%)		Total energy consumption (Kcal)	
B														
2006	32.5	(30.57, 34.49)	27.0	(24.96,29.18)	65.2	(62.99, 67.26)	90.1	(88.91, 91.23)	79.4	(77.43, 81.23)	15.79	(15.63, 15.95)	1514.60	(1501.9, 1527.3)
2012	45.1	(40.73, 49.55)	29.8	(25.63,34.31)	74.4	(69.76, 78.62)	90.8	(87.95, 93.08)	75.1	(70.89, 78.82)	19.42	(18.939, 19.89)	1723.27	(1690.6, 1755.9)
2016	48.2	(44.4, 52.02)	45.3	(41.68,48.98)	64.4	(60.88, 67.83)	89.8	(87.37, 91.8)	84.8	(81.55, 87.49)	19.56	(19.23, 19.89)	1612.69	(1589.7, 1635.7)
2018	43.6	(41.44, 45.86)	22.0	(20.22, 23.97)	63.9	(61.88, 65.89)	92.7	(91.57, 93.66)	85.5	(83.57, 87.19)	18.12	(17.9, 18.34)	1607.04	(1591.5, 1622.5)
2020	51.6	(46.92, 56.33)	30.5	(26.11, 35.23)	54.1	(49.03, 59.17)	91.4	(88.18, 93.78)	88.0	(84.08, 91.02)	21.31	(20.56, 22.05)	1714.96	(1669.6, 1760.3)
2021	43.6	(38.66, 48.68)	24.1	(19.68, 29.2)	51.0	(45.92, 56.13)	94.1	(91.3, 95.98)	92.3	(89.73, 94.33)	19.74	(18.99, 20.5)	1646.12	(1598.8, 1693.4)
Total	44.1	(42.46, 45.69)	32.2	(30.71, 33.78)	62.2	(60.64, 63.76)	91.2	(90.2, 92.01)	84.7	(83.43, 85.9)	17.6	(17.49, 17.72)	1581.38	(1572.9, 1589.9)

ENSANUT 2006, 2012, 2016, 2018-19, 2020 and 2021. Mexico.

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TABLE 3 Linear mixed model for the contribution of food group intake on overweight + obesity.

Overweight + obesity	Coefficient	*P*-value	95% CI	
			95% LB	95% UB
ENSANUT	0.0041	0.000	0.0024	0.0059
Fruit consumption	−0.066	0.010	−0.116	−0.016
Vegetable consumption	−0.083	0.000	−0.128	−0.038
Snacks, candies, and dessert consumption	0.041	0.112	−0.010	0.092
Sugar-sweetened beverage consumption	0.075	0.098	−0.014	0.164
Age (years)	0.028	0.000	0.024	0.032
Sex: female	−0.042	0.000	−0.059	−0.025
Area: rural	−0.028	0.002	−0.045	−0.011
Wellbeing condition: medium	0.066	0.000	0.044	0.088
Wellbeing condition: high	0.129	0.000	0.105	0.153
Constant	−8.226	0.000	−11.769	−4.683

density, lower consumption of fiber, and structural factors previously reported (21, 22) such as belonging to a higher socioeconomic class, residing in urban localities, as well as with age and sex.

Notably, we observed that a decrease in overweight was reported throughout the survey years, at the expense of increases in obesity, where today these two outcomes show similar behavior. In Mexico, OW and OB together in the year 2006 showed a prevalence of 34.8%; in the year 2020 this rose to 38.2%, where prevalence of OW was 20.2 and 19.6%, respectively, and prevalence of OB was 14.6% and rose four percentage points (2).

The pseudo-panels of the study showed that those food groups considered as protective, such as fruits and vegetables, protected against overweight and obesity in school-age children. On the other hand, intake of snack foods, sweets and desserts, and sugar-sweetened beverages were associated with the presence of both outcomes. This has been documented both at the national level in Mexico as well as internationally, where the consumption of foods and drinks with high energy density, fat content, and added sugars in the place of natural foods (23, 24). These types of foods generally imply a process, and it has been argued that the marketing of these unhealthy products affects attitudes, preferences, and consumption of unhealthy foods in both children and adults, leading to excessive weight gain (25, 26).

We also found that greater fiber consumption was associated with lower overweight and obesity in school-age children, even when this association was not statistically significant. Although this association is inconclusive in the scientific literature, we suggest that a greater fiber content in food items indicates a lower caloric density, as well as a lower consumption rate and possibly a greater sense of satiety (27). Furthermore, the low consumption of fruits and vegetables in the diets of children has not generally been an area of focus, which is problematic considering the nutritional benefits of these foods and their protection against chronic diseases (28). The consumption of fruits and vegetables also assures a higher consumption of fiber, a key player in the prevention and reduction of non-transmissible conditions such as constipation: a common problem among children (29). Evidence suggests that if fruit and vegetables consumption occurs from childhood, healthy dietary habits are likely to be adopted in the long term (30).

Our results are comparable with previous studies in children which report lower indices of overweight and obesity with higher consumption of fiber (31). This may be attributable to the fact that median fiber intake is far below the recommended amount (32) for which the increase in food items high in fiber would be recommendable to strengthen this association and reduce the risk of other chronic diseases (33).

Also, as previously documented, structural variables which affirm the association of obesity with the level of general wellbeing of the school-age population are of concern. In the present study, we find that the prevalence of OB increases with increased wellbeing condition by the WBI. Previous studies have reported a wide variation in the prevalence of OW and OB in the school-age population, oscillating from 2.9 to 44.4% across different countries worldwide (34, 35), showing a considerable impact from familial socioeconomic conditions (36). Furthermore, statistically significant differences by gender have been recorded in Mexico, where the ENSANUT surveys show that across survey years the prevalence of OW and OB is higher in men (37).

This has varied implications, given the evidence that in developed countries, whose populations have experienced improvements in socioeconomic status, improvements in health have also been documented in relation to an improved access to health care. This improvement in low- and middle-income countries could mean greater mechanization, leading to lower daily activity levels and an increased access to ultra-processed foods and fast foods (38).

In children residing in rural areas, prevalence of both overweight and obesity is lower. In this sense, our results are congruent with previous results in Mexico (39) and in other Latin American countries and developing countries, where the results of gradual growth of urban areas, especially in poor urban zones (40) where migrants from rural zones tend to settle, generate changes in the conditions in which people live. These changes, linked to changes in available infrastructure, such as less movement linked to public transport and in daily activities, and in general greater sedentarism, in conjunction with changes in dietary habits (41) stemming from a greater availability of ultra-processed foods, have been linked to obesity epidemics. In this sense, each country presents a specific point in the transition toward epidemic obesity, although in general, this has initially presented itself in groups of higher socioeconomic status, and later concentrates in poorer socioeconomic groups (42).

Our study has the specific strength of its instruments being validated and used in national-level surveys in Mexico, and that anthropometric measures have been performed by trained and standardized staff. The information used is from national-level samples with the same design, which allows comparison and extrapolation of results within the national population. Furthermore, by using a pseudo-panel analysis, we could confirm that the information across various survey years was consistent and from the point of view of analysis with a lineal regression model, the possibility of bias by omission of fixed variables is lowered. This is due to the methodology which controls for unobservable heterogeneity which may be assumed as invariable over time (43), as well as the fact that the sample shows no losses across time which allows-unlike an original panel design-the number of cohorts to remain constant (44).

Among the limitations of this study is that, due to being a sequence of surveys, as well as the nature of transversal studies and the lack of continuity in public policy and related interventions, we cannot infer causality and therefore, effects. Nevertheless, we were able to observe trends over the time period of reference.

Another limitation is that the survey design does not include physical activity in children in every year that the survey was conducted, thus, it was not possible to include this variable in the pseudo-panel analysis.

Notably, when facing a problem of the magnitude of school-age child obesity, permanent government strategies and actions are required to ensure the containment, prevention, and management of this outcome in order to avoid serious consequences for long-term health and national development. To the present, various strategies have been implemented in Mexico (8, 45, 46), as well as in other countries around the world (47, 48). Although these have been associated with some positive results, they are not public policy actions which demonstrate an overall effective impact.

An example of this is the establishment of regulations on the sale and distribution of foods and drinks in the school environment dating back to 2010, and which were only put in place in 2012 and whose implementation was monitored only starting in 2015. The results of the implementation evaluation during the study years showed that only a small portion of children ate healthy food items in school. Compliance with the regulations by schools increases the probability of healthy lunches if they are bought in the school, which suggested that better implementation of standards and additional strategies are necessary to improve public policies which achieve the objective to reduce childhood obesity (49). Nevertheless, to the present this strategy has not been implemented or consolidated.

Other actions implemented on the national stage and not only targeting the school-age population include the 2014 tax of one Mexican peso on sugar-sweetened beverages (50), and one previous study found a reduction of 6% in buying of taxed beverages in 2014. Furthermore, from 2014 to 2015 changes were observed in the buying of taxed and non-taxed beverages, where buying of taxed beverages diminished by 5.5% in 2014 and 9.7% in 2015: an average reduction of 7.6% over the study period. Lower income households showed greater reductions in buying of taxed beverages during both study years (51). Buying of non-taxed beverages increased by 2.1% during the study period. Nonetheless, the tax is too small to expect the provocation of biological impacts such as a reduction in obesity. In fact, in our analysis, we observed that the consumption of sweetened beverages is so widely generalized in this population (about 90%), that the low variability increases the difficulty of associations detection.

After a difficult battle, a change was achieved in nutritional labeling in Mexico with the recently introduced frontal warning label. This was based on evidence of a national sample showing that in 2016 the most referenced label in the selection of industrialized food and drink items was the "nutritional table" at 41.5% (IC95% 36.9–46.3) of respondents, and lesser use was made of the "food label" at 4.3% (IC95% 3.1–5.7). This finding led to the proposal of a quick to read and readily understandable frontal nutritional label, which would show key nutritional criteria compliant with existing official nutritional standards recognized by the WHO, such as percent of consumption based on sugar, in an effort to address the diabetes epidemic in the country (52).

On the other hand, given the current state of global food systems, Mexico's current government launched the Intersectoral Health, Food, Environment and Competitivity Group (GISAMAC for its Spanish acronym) (53), formed by six federal departments with the participation of the Agricultural

Office and sectoral bodies from each entity. Based on the guidelines of the EAT Lancet Commission (54, 55) which highlight the need for cross-cutting environmental policies which promote the availability and consumption of foods which are sustainable, affordable and healthy for the planet and therefore, for the population. Part of this included a focus on establishing within educational settings short supply chains for consumption of local foods, school gardens, food and nutrition education strategies which put children in a leading role, as well as the regulation of food and beverage marketing directed at children.

The consideration of preventative approaches to early and childhood obesity increases early detection, improves the quality of childhood care options, and offers an evidence-based communication plan for behavior change around overweight and obesity which is focused on life course and has national reach. However, the implementation and progression of this approach was stymied by the COVID-19 pandemic and is currently being retaken.

In conclusion, overweight and obesity in school-age children is a continuing problem with serious repercussions for the future. Despite carrying out a variety of individual- and global-level public policy actions for the containment, prevention, and control of this condition, structural factors exist which require early action and significant investment, especially given the integral nature of the actions needed across sectors such as health, education, economy, social development, environment, and agriculture. These actions are needed in order to modify and construct a healthy and sustainable food system in Mexico, and a healthy and sustainable diet to children.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: https://ensanut.insp.mx.

Ethics statement

The studies involving human participants were reviewed and approved by Institutional Research Ethics Committee, National Institute of Public Health of Mexico. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Targeting food parenting practices to prevent early child obesity risk requires a different approach in families with a lower socioeconomic position

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Introduction

Childhood obesity is a serious public health epidemic that occurs more frequently among children from families with a lower socioeconomic position (SEP) (1). It has generally been acknowledged that facets of the current dietary environment contribute to increased obesity vulnerability among children (2). Parents are considered a key influence in children's home food environments, particularly during early childhood (3, 4). Specifically, the home food environment is largely shaped through parents' food parenting practices (5), which refer to food-specific, goal-oriented, discrete, and observable acts of parenting (6). As dietary habits formed during early childhood may have a lifelong influence on food preferences, understanding how to promote healthy eating habits in children by influencing at-risk parents during this stage of life is very important and cost-effective (3, 7, 8). Hence, this opinion article aims to increase insight into how we can best improve food parenting practices among parents of young children from lower SEP backgrounds. To this aim, we first summarize recent food parenting practices insights from systematic reviews containing experimental, intervention, or longitudinal studies that are able to show cause-and-effect or direction of relations. Then, we will discuss high quality studies specifically examining effects of food parenting practices among parents of young children with lower SEP and consider the broader context of the potential consequences of lower SEP, because this sets the stage for intervention efforts. Finally, we will integrate and discuss these findings and provide recommendations for future research. Of note, this perspective focuses on parenting practices regarding child dietary intake, with the acknowledgment that environmental obesity influences are naturally not limited to diet.

Food parenting practices: Insights from intervention, experimental, and longitudinal review studies

In general, three overarching dimensions of food parenting practices have been distinguished. First, structure, consisting of practices such as food rules and limits, monitoring, routines, modeling, repeated exposure, and food availability and accessibility. Second, coercive control, with practices dominating child behavior, such as restriction, threats, and instrumental or emotional feeding. Third, autonomy support, including practices that facilitate children's independence and healthy eating through for instance encouraging the child to eat autonomously, praise and non-food rewards, nutrition education, reasoning, and negotiation (9). During the past decade, reviews of experimental and (home-based) intervention studies have improved our knowledge of the influence of food parenting practices on the development of children's healthy dietary intake, although studies most often have a bias toward parents from higher SEP backgrounds. Most evidence has been found for repeated exposure to a variety of vegetables, serving a variety of vegetables, and small (non-food) rewards (10–14). Moreover, simply providing children with healthy food (i.e., availability) has been experimentally shown to affect long-term eating behavior (15). Other promising, but less examined, strategies to stimulate healthy food intake include social modeling, guided choices, portion size, and experiential learning strategies (14–16). Of note, less is known about whether and how food parenting practices may prevent children's intake of less healthy foods, while these insights may even be considered more directly important for effective childhood obesity prevention (14).

To gain more insight into the prospective links between food parenting practices and (early) children's weight outcomes we have recently provided a systematic overview of such links (17). Coercive practices, specifically restriction, pressure, and monitoring, receiving the most attention within prospective studies were generally *not* associated with children's weight outcomes over time. Instrumental feeding, and thus rewarding with food for correct behaviors, was found to be associated with higher weight over time, but more high-quality research is needed. Similarly, most autonomy supporting and structure-related food parenting practices were also important understudied constructs (17). Of note, in contrast to the longitudinal zero findings for restriction, systematic reviews (partly) based on experimental studies suggest that restriction is associated with higher intake of restricted/unhealthy foods (15, 16, 18). Future experimental studies with longer-term follow-ups may unravel these seemingly contradicting findings, taking reversed causation effects into account.

Finally, reviews of intervention studies suggest that responsive feeding is promising in the prevention of childhood obesity (19). Responsive feeding interventions stimulate child-centered and autonomy supportive food parenting practices that encourage self-regulation in eating (and discourage coercive practices) through supporting the child to eat autonomously and in response to physiological and developmental needs (20). Systematic reviews of randomized controlled trials suggest that providing responsive feeding and/or broader responsive guidance to parents compared to usual care, can stimulate more "normal" healthy weight development during infancy and preschool age (21–23). However, it should be noted that these responsive intervention studies are population-based studies that often target broader (responsive) parenting and weight-related strategies and also have a bias toward parents with higher SEP backgrounds. This SEP bias is a common trend, with many preventive (dietary) interventions not targeting young children most at risk of childhood obesity (24, 25).

Food parenting practices in families with lower SEP: What is known?

Although studies on food parenting practices among families with higher SEP outnumber those among families with lower SEP, some relevant studies have been conducted among families with lower SEP. Most high-quality studies among parents with lower SEP have investigated feeding styles instead of food parenting practices, so direct comparisons are difficult to make. Feeding styles are usually described along the same dimensions as general parenting styles (i.e., demandingness and responsiveness) (26) but are specifically applied to the eating context, and refer to the overall context in which parents socialize their children around eating (27). To date, an indulgent feeding style (low demandingness/high responsiveness) has consistently been linked with increases in Body Mass Index z-scores over time among preschoolers living in low-income households (28–30). Remarkably, while general authoritative parenting is considered the most "healthy"—relating to numerous positive child outcomes—the authoritative *feeding* style was also related to higher child z-BMI in two out of three previously reported studies among low-income families (29, 30). Future research is needed to replicate this finding and understand what mechanisms may underlie this association. One eminent mechanism may relate to (unhealthy) food availability in the household, explaining why allowing children autonomy in what and how much they eat does not lead to healthy weight outcomes. The importance of food availability and accessibility for lower SEP families is underscored in a recent study showing that these food parenting practices were the most important ones mediating the association between parental education (i.e., important indicator of SEP) and children's dietary intake (31). Moreover, review studies suggest that healthy food modeling is also less common among families with lower

SEP (32, 33). Besides, we suggest that many promising food parenting practices previously mentioned do not work equally effective for parents from lower SEP backgrounds without taking the broader perspective and SEP barriers into account, as further discussed below.

Barriers impeding food parenting practices among parents with lower SEP

Can interventions that work in families from higher SEP automatically be assumed to work equally well in families with lower SEP backgrounds? Are determinants of food parenting practices the same in these differing groups? Are the same problems in food parenting practices present, or should we target different behavior? Families from lower SEP obviously entail a large range of diverse families, the defining features being a lower educational/occupational level of the parent(s), and/or less available income for the family, which may cause financial problems. It is well known that lower SEP is a risk factor for parental stress and lower mental wellbeing (34, 35), which each pose a risk for using more negative general parenting strategies (36, 37). Thus, families from lower SEP backgrounds may be confronted with a combination of risk factors which are likely to exacerbate each other. In the case of promoting a healthy diet, financial problems are an important barrier because unfortunately, foods of lower nutritional value still cost less per calorie and are thus more often selected by parents with lower SEP backgrounds (38). Besides food cost, lack of (nutrition) knowledge and time are often reported barriers toward healthy eating and weight status (39) that are more frequently reported among parents from lower SEP (31, 40). In addition, although parents from lower SEP, like parents from higher SEP, have more positive attitudes toward healthy food choices (41), healthfulness misperceptions are more common among "low-income" parents and appear to contribute to frequent provision of unhealthy dietary products to children (42–44). Moreover, families from lower SEP more often live in unhealthy neighborhoods with fast-food stores and less opportunities to buy healthy groceries, impacting food parenting practices, children's dietary intake, and weight development (45, 46). Taken together, it is highly likely that food parenting interventions for families with a lower SEP will require a different approach.

Discussion and directions for future research

We therefore propose to simultaneously target three key aspects to improve food parenting practices among parents from lower SEP backgrounds, thereby "bridging" multiple socio-ecological layers at the interrelated individual, (food) environmental, and social/interpersonal level (47–50).

Recommendation 1: Tailor to individual-level needs

A first action we propose is that, at the individual level, food parenting interventions should be tailored to the specific (mental health) needs, knowledge, and motivations of parents from lower SEP previously mentioned. Cultural diversity is also an important topic to consider, with interventions needing culturally sensitive tailoring, both regarding delivery and content (51). We even propose that tailoring the preventive approach to the needs and wishes of parents through participatory design principles is more relevant than including all evidence-based advices in terms of healthy parenting changes, as motivation is a core component that need to be fulfilled in order for a behavior change intervention to be effective (52, 53). Specifically, tailored at mental health needs, mindfulness (parenting) interventions may have great promise among some underserved (e.g., lower SEP) populations (54), as they address automatic processes underlying health (and parenting) behaviors that may particularly be important for these groups that often experience more problems with translating intentions into behaviors (55, 56).

Recommendation 2: Make healthy food easily available

A second action we propose is to improve broader environmental-level food availability and accessibility, given the previously mentioned barriers impeding healthy child consumption. Of note, strategies focusing on tax and subsidy policies particularly benefit lower SEP groups (57). Moreover, incentives that promote healthier food purchases are rare, but may also prove promising (58). These policy changes influence broader environments and regulations, helping parents from lower SEP backgrounds to make healthy foods more easily available in their homes, facilitating important food parenting practices (e.g., healthy food availability/accessibility or modeling) that, as mentioned, are generally less common among families with lower SEP backgrounds (31–33).

Recommendation 3: Target and deploy the social network

A final action we propose is that interventions should actively use the social context in which parents live. Parents from lower SEP may have developed greater attunement to other people and social information/relationships (59). As such, they might also be impacted more strongly by an integral approach targeting the social/interpersonal level. There is evidence that whole-of-community interventions are more effective for people with lower than higher SEP backgrounds (60). Parent support groups are appreciated by parents of young children and seem to contribute to enhancing parental knowledge, skills and practices regarding healthy behaviors, potentially benefitting young children's health behaviors (61). Moreover, a systematic review also supports the idea that interventions involving more active parental engagement strategies, such as social support, are more effective in the prevention of early childhood obesity (62). Hence, we propose that social network strengths should be more actively targeted and deployed in the field of food parenting practices (and broader obesity prevention efforts).

Conclusion

This opinion article shows that more research is needed to examine how food parenting practices can best be targeted among "lower SEP" families. We propose that targeting structure-related food parenting practices (e.g., availability/accessibility) should have high priority among these groups. Only then, responsive (feeding) interventions may reach similar positive effects to those among parents with a generally higher SEP. Moreover, we propose that for intervening on food parenting practices among these groups, an active integral approach, "bridging" diverse socio-ecological layers, is highly important. One example to bridge the layers, is that individual-level techniques to change automatic processes underlying stress, health behaviors, and parenting behaviors are targeted at the social/interpersonal level (actions performed together with a friend or partner). Another example is to combine environmental availability of fruit and vegetables (e.g., through preschools and free provision to parents) with specific individual-level food parenting interventions. Such examples should preferably be combined, bridging all three layers. The purpose of this opinion article is to contribute to a foundation for stimulating innovative and promising lines of food parenting intervention research that actively bridge the socio-ecological layers to more effectively prevent childhood obesity among high priority populations.

Author contributions

JL conceived the idea and wrote the first draft of the manuscript. LK and SV edited the manuscript. All authors read and approved the final version of the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Parent and child dietary changes in a 6-month mobile-delivered weight loss intervention with tailored messaging for parents

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Objective: To examine changes in parent and child dietary intake, associations between program adherence and parent dietary changes, and the association between parent and child dietary changes in a mobile-delivered weight loss intervention for parents with personalized messaging.

Methods: Adults with overweight or obesity and who had a child aged 2–12 in the home were recruited for a randomized controlled trial comparing two types of dietary monitoring: calorie monitoring (Standard, $n = 37$) or "red" food monitoring (Simplified, $n = 35$). Parents received an intervention delivered *via* a smartphone application with lessons, text messages, and weekly personalized feedback, and self-monitoring of diet, activity, and weight. To measure associations between parent and child dietary changes, two 24-h recalls for parents and children at baseline and 6 months measured average daily calories, percent of calories from fat, vegetables, fruit, protein, dairy, whole grains, refined grains, added sugars, percent of calories from added sugars, and total Healthy Eating Index-2015 score.

Results: Higher parent engagement was associated with lower parent percent of calories from fat, and greater days meeting the dietary goal was associated with lower parent daily calories and refined grains. Adjusting for child age, number of children in the home, parent baseline BMI, and treatment group, there were significant positive associations between parent and child daily calories, whole grains, and refined grains. Parent-child dietary associations were not moderated by treatment group.

Conclusions: These results suggest that parent dietary changes in an adult weight loss program may indirectly influence child diet.

KEYWORDS

intervention, parents, children, nutrition, text message

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Introduction

The rates of obesity in adults and children in the United States remain a public health concern, as 42% of adults had obesity and 19.3% of children aged 2–19 had obesity in 2013–2016 (1, 2). Obesity in childhood increases the risk of obesity and its comorbidities (e.g., heart disease, type 2 diabetes, and cancer) in adulthood (3–5), which highlights the need to improve dietary and activity behaviors starting at an early age. Targeting dietary intake in the home is a critical avenue for prevention, as children aged 4–13 are, on average, only meeting about 50% of the requirements for a healthy diet (6), and ∼65% of the calories consumed by children are consumed in the home (7–9). Aspects of the home environment such as parent food intake, family meals, and availability of healthy foods are known to impact child dietary intake (10–20). Moreover, epidemiological research has consistently shown that children who have at least one parent who is overweight or obese are at high risk of gaining excess weight in childhood (21, 22). While the associations between parent and child weight and dietary intake have been well documented, less is known about how to target parent dietary behaviors and changes in the home environment to produce changes in child dietary behaviors.

There is some evidence showing that interventions that target parent weight loss can indirectly have a positive effect on child weight (23–27), which suggests that the mechanisms that improve parent weight status, such as changes in the home food and activity environment, also impact the child. There is also evidence that interventions targeting the entire family can have an impact on child dietary changes. For example, a study targeting an increase in family meals with parents and their children ages 8–12 found that children in the intervention group were less likely to consume SSB daily compared to the control group (28), and a food parenting intervention targeting low-income mothers as the agent of change for dietary intake in preschool-aged children found that children reduced their intake of energy from solid fats and added sugars (SoFAS) at 12 weeks (29). These two studies did not measure parent dietary intake, which precludes the ability to measure whether child dietary changes were associated with parent changes. Other family-based programs have measured both parent and child dietary intake and found parent-child associations in dietary changes, including fruit and vegetable intake among parents and their preschool-aged children (30), changes in high-calorie "red" foods and fruits and vegetables among parents and children ages 7-12 (31), consumption of grains among fathers and their children ages 5–12 (32), fruit, carbohydrates, and meals with vegetables among fathers and their children ages 5–12 (33), and energy intake from core (healthy) foods, nutrient-dense unhealthy foods, fast foods, breakfast cereals, and SSBs (34). All of these studies required intensive in-person contact with both the parents and children (30–34). Larger public health impact might be achieved if lower intensity programs that reduce parent and child contact time were readily available. However, little is known about whether parent dietary changes within a parent-only intervention have an impact on child dietary behaviors.

Two studies have exclusively targeted parents with overweight or obesity and measured both parent and child dietary outcomes. One study included a 3-month telephone coaching intervention for parents of children ages 2–10 (35) and did not produce changes in any parent or child dietary components. The other, a 6-month individual- and group-based counseling weight management program for parents of children age 7–18, measured fruit and vegetable intake at all time points, but resulted in no changes in parent or child intake (36). Given the importance of parent dietary behaviors and the home environment, it is critical to determine the most efficient and efficacious way to involve parents as the agent of change in promoting positive dietary changes in children.

The objective of this study was to examine data from a completed 6-month behavioral weight loss intervention for parents, the PATH (PArents Tracking for Health) study (37), that included personalized messaging *via* text and smartphone app to examine: (1) changes in parent and child dietary intake components from baseline to 6 months, (2) the associations between parent program adherence and parent dietary changes, and (3) the associations between parent and child dietary changes and if treatment group moderated any of these associations.

Methods

Study design and participants

The primary aim of the PATH randomized trial was to compare the efficacy of two smartphone-delivered behavioral interventions that differed in the approach to dietary self-monitoring, with either standard calorie monitoring (Standard) or simplified monitoring of high-calorie "red" foods (Simplified) (37). Given that parents are busy and may need simpler alternatives to weight loss that don't require detailed daily tracking of calories (38, 39), the Simplified group used a Traffic Light approach that categorizes foods as green, yellow, or red (40), and tracked only "red" foods (high-calorie foods such as sweetened beverages, desserts, processed salty snacks, fried foods, etc.). The Institutional Review Board at University of North Carolina approved the study. Recruitment of parent-child dyads occurred in 2019 primarily *via* email listservs and social media. Eligible individuals had a BMI between 25 and 50 kg/m^2, were between the ages of 21 and 55, had at least one child in the home aged 2–12, were not currently pregnant or pregnant in the last 6 months, participated in <150 min of moderate-to-vigorous physical activity a week, and neither the adult or child participant had pre-existing medical condition(s) that preclude adherence to dietary changes or exercise. Parents completed informed consent for their own participation and their child's participation, and children aged 7–12 completed an assent form. Parent-child dyads ($N = 72$) were randomly assigned to the standard calorie monitoring group (Standard) or simplified monitoring group (Simplified).

Intervention elements in both groups

The intervention was based on Social Cognitive Theory and targeted constructs including self-regulation, self-efficacy, outcome expectations, perceived barriers, and observational learning (41). Parents were the primary target of the intervention. Children did not receive any direct intervention contact or guidance for activity and dietary changes. Hereafter, "participants" refers to parents, unless otherwise specified. Participants in both groups attended one in-person group session, followed by a remote program delivered *via* lessons and personalized automated weekly feedback in the PATH study smartphone app, plus 4–5 tailored text messages each week. Participants had three daily goals: (1) self-weigh on their smart scale, (2) wear their Fitbit activity tracker and meet a daily activity goal that gradually increased throughout the study as they met their goals, and (3) track their dietary intake and meet their daily goal. The 18 behavioral lessons addressed topics such as modeling healthy eating and exercise, setting limits, snacking and screen time, and parent-child communication. Lessons primarily addressed adult behavior change but were framed in the context of having children in the home, acknowledging that all members of the family unit can be barriers or facilitators to change, and that parent changes in healthy behaviors can have a positive impact on the child's behaviors. In addition, the app for both groups included a "Family Corner" section that advised on how to apply the information and strategies learned with their children in the home. Approximately 1 of the 5 text messages every other week focused on parenting skills that can promote positive and healthy behaviors in the home (Supplementary Table 1). The remaining text messages included alerts that new lessons and feedback were available in the app, motivational messages, and messages tailored to the parents' progress toward their dietary, activity, and self-weighing goals.

Standard group dietary self-monitoring

Participants in the Standard group received a calorie goal (1,200–1,800 kcal/day) and tracked their calories in the Fitbit smartphone app. Messages they received about dietary intake were specific to calorie tracking and their calorie goal.

Simplified group dietary self-monitoring

Participants in the Simplified group used the Traffic Light approach that categorizes foods as green, yellow, or red. They received a red food limit of 3–5 per day and tracked only "red" foods (high-calorie foods such as sweetened beverages, desserts, processed salty snacks, fried foods, etc.) in a Food Log within the PATH study app. Only participants in the Simplified group had access to this Food Log. Messages they received about dietary intake were adapted directly from the calorie messages to be specific to red food tracking and their red food limit.

Measures

Dietary intake

Dietary intake was assessed using 24-h dietary recalls with blinded, trained dietary assessment staff *via* telephone at baseline and 6 months. Participants completed two telephone 24-h dietary recalls per parent and child at each time point (two parent dietary recalls and two parent-reported child dietary recalls). Staff were instructed to conduct the parent and child dietary recalls on the same day, when possible. Dietary recall information was entered directly into the Nutrition Data System for Research (NDSR), which was used to calculate average daily intake of the following dietary components for both the parent and child: total caloric intake (total kcal/day), percent of intake from fat (pct fat/day), total vegetables in cups (total veg/day), total fruit in cups (total fruit/day), protein in ounces (protein/day), dairy in cups (dairy/day), whole grains in ounces (whole grain/day), refined grains in ounces (refined grains/day), added sugars in grams (added sugars/day), percent of intake from added sugars (pct added sugar/day), and the Healthy Eating Index 2015 total score, a measure of diet quality based on the Dietary Guidelines for Americans (ranges from 0 to 100, with higher scores indicating better diet quality) (42).

Anthropometrics

Weight and height of parents were objectively measured by trained staff blinded to treatment assignment following a standardized protocol. Measurements were taken twice (three times when not within 0.1 kg and 0.1 cm for weight and height, respectively) and averaged. Weight and height was used to calculate baseline body mass index (BMI; kg/m^2). Parents completed their child's weight and height assessments at their home. The child stepped on the parent's smart scale two times in a row, and the parent used a CDC standardized protocol to measure the child's height in centimeters two times in a row (43), then entered the child's weights and heights into an online form. The child's age, sex, and at-home weight and height measurements were used to calculate BMI z-scores based on the Centers for Disease Control and Prevention growth charts (44).

Program adherence and engagement

Dietary self-monitoring data (Fitbit food logs for the Standard group and PATH app Food Log data for the Simplified group) was the primary measure of program adherence and was used to calculate the average number of days per week that participants met their dietary goal (i.e., tracked their dietary intake and stayed at or below their calorie goal or red food limit; range 0–7). Program engagement was operationalized as number of total days that the PATH app was opened (range 0–184).

Statistical analyses

Descriptive statistics were calculated for demographic variables and dietary component variables at baseline and 6 months for parents and children. Demographic variables were tested for their association with 6-month dietary outcomes using ANOVA for continuous variables and chi-square tests for categorical variables, and significant confounders were included as covariates in all analyses. Paired *t*-tests were used to test for changes over time in parent and child dietary component variables. To examine the association between parent adherence to the program and parent dietary changes, separate models regressed the 6-month value of the parent dietary component on (1) average number of days/week meeting the dietary goal, and (2) total days of app usage, controlling for baseline value of the dietary component, baseline BMI, number of children in the home, and treatment group. To determine the unadjusted association between change in parent dietary components and child dietary components from baseline to 6 months, linear regression was used to regress the 6-month value of the child dietary component on the parent 6-month value of the

TABLE 1 Baseline characteristics by treatment group.

Characteristic	**Standard (*n* = 37) Mean ± SD or *n* (%)**	**Simplified (*n* = 35) Mean ± SD or *n* (%)**	**All participants (*N* = 72) Mean ± SD or *n* (%)**
Age	39.8 ± 4.7	40.2 ± 4.7	40.0 ± 4.6
Female	35 (94.6)	33 (94.3)	68 (94.4)
Ethnicity			
Hispanic/Latino	0 (0.0)	2 (5.7)	2 (2.8)
Non-Hispanic/Latino	37 (100.0)	33 (94.3)	70 (97.2)
Race			
Asian	0 (0.0)	1 (2.9)	1 (1.4)
Black or African American	5 (13.5)	4 (11.4)	9 (12.5)
Hispanic, Latino, or Cape Verdean	3 (8.1)	0 (0.0)	3 (4.2)
White	29 (78.4)	28 (80.0)	57 (79.2)
Other[a]	0 (0.0)	2 (5.7)	2 (2.8)
Education			
High school, vocational training, or some college	1 (2.7)	4 (11.4)	5 (6.9)
Bachelor's degree	17 (46.0)	10 (28.6)	27 (37.5)
Graduate or professional degree	19 (51.4)	21 (60.0)	40 (55.6)
Marital status			
Married or living with partner	35 (94.6)	29 (82.9)	64 (88.9)
Not married or living with partner	2 (5.4)	6 (17.1)	8 (11.1)
Weight (kg)	99.1 ± 21.6	91.0 ± 15.9	95.2 ± 19.3
BMI (kg/m^2)	35.3 ± 6.8	33.07 ± 5.7	34.2 ± 6.4
Mean number of children in home	1.9 ± 0.7	2.0 ± 0.9	2.0 ± 0.8
Child age (years)	6.0 ± 6.8	6.8 ± 2.6	6.4 ± 2.9
Child female	21 (56.8)	21 (60.0)	42 (58.3)
Child in school or full-day childcare	33 (89.2)	30 (85.7)	63 (87.5)
Child weight (kg)[b]	24.3 ± 10.0	28.3 ± 14.0	26.3 ± 12.2
Child BMI z-score[b]	0.47 ± 1.42	0.47 ± 1.35	0.47 ± 1.37

[a]Other = checked response option "Other" and race is unknown.
[b]Out of n = 34 available child measurements in Standard and n = 34 in Simplified.

same dietary component, controlling for the child and parent's baseline values of that dietary component. An adjusted model controlled for child age in months, parent baseline BMI, number of children in the home, and treatment group. To determine if the parent-child dietary associations varied by treatment group, an additional model included all prior covariates plus an interaction term for treatment group by parent change in the dietary component.

Results

The baseline characteristics of the original study sample are presented in Table 1. Parents were, on average, 40.0 years old (SD = 4.6), with a baseline BMI of 34.2 (SD = 6.4), and 94% female. Index children were an average of 6.4 years old (SD = 2.9), with an average BMI z-score of 0.47 (SD = 1.37), and 58% were female. Parent baseline BMI, child age, and number of children in the home were associated with changes in dietary component variables and were included as covariates in the analyses. All participants completed parent and child dietary recalls at baseline. At 6 months, 66 participants (92%) completed parent dietary recalls and 66 (92%) completed child dietary recalls, with no difference by treatment group ($p = 0.68$).

Changes in parent and child dietary components

Means and standard deviations for baseline and 6-month values and means and confidence intervals for change values for all dietary components are reported in Table 2. There was a significant reduction in parents' total kcal (-271.6 kcal/day; 95% CI: −457.2, −86.1; $p < 0.01$), added sugars (−16.2 g/day; 95% CI: −27.0, −5.3; $p < 0.01$), and percent of kcal from added sugars (−2.24%; 95% CI: −4.05, −0.44; $p < 0.05$) from baseline to 6 months. There were no significant changes in any child dietary variables from baseline to 6 months.

Association between parent adherence and engagement and dietary changes

Average number of days a week meeting the dietary goal was negatively associated with parent change in total kcal, such that each additional day of meeting a dietary goal per week was associated with a reduction of 89 kcal ($p < 0.05$; Table 3). In addition, each additional day of meeting a dietary goal per week was associated with a reduction of 0.43 ounces of refined grains ($p < 0.05$). Total days of app usage was negatively associated with percent of fat from calories, such that each additional day using the app was associated with a 0.06% reduction ($p = 0.05$).

TABLE 2 Means and standard deviations of dietary component variables for $n = 66$ parents and children with dietary data at both time points.

	Baseline Mean (SD)	6 Months Mean (SD)	Change Mean (95% CI)
Average kcal/day			
Parent	1,743.2 (594.2)	1,471.6 (543.2)	−271.6 (−457.2, −86.1)**
Child	1,451.6 (353.0)	1,507.6 (463.7)	56.0 (−68.2, 180.3)
Average pct fat/day (%)			
Parent	37.57 (8.73)	37.24 (9.57)	−0.33 (−3.20, 2.54)
Child	32.71 (6.50)	33.23 (6.62)	0.52 (−1.44, 2.48)
Average total veg/day (cup)			
Parent	1.59 (1.18)	1.57 (1.05)	−0.02 (−0.34, 0.30)
Child	0.60 (0.67)	0.72 (0.77)	0.12 (−0.10, 0.33)
Average total fruit/day (cup)			
Parent	0.59 (0.89)	0.55 (0.65)	−0.05 (−0.28, 0.18)
Child	1.07 (0.72)	1.06 (0.83)	−0.01 (−0.24, 0.22)
Average whole grains/day (oz)			
Parent	1.67 (1.94)	1.39 (1.51)	−0.28 (−0.82, 0.26)
Child	1.28 (1.48)	1.40 (1.21)	0.12 (−0.27, 0.51)
Average dairy/day (cup)			
Parent	1.32 (0.99)	1.03 (0.89)	−0.30 (−0.60, 0.01)
Child	1.98 (1.15)	1.92 (1.31)	−0.06 (−0.40, 0.29)
Average total protein/day (oz)			
Parent	5.62 (2.98)	5.45 (3.14)	−0.17 (−1.20, 0.86)
Child	3.26 (1.76)	3.67 (1.91)	0.41 (−0.20, 1.01)
Average refined grain/day (oz)			
Parent	4.34 (2.76)	3.69 (2.99)	−0.65 (−1.60, 0.31)
Child	4.83 (2.60)	4.86 (3.01)	0.03 (−0.87, 0.93)
Average added sugar/day (g)			
Parent	46.9 (38.3)	30.7 (28.4)	−16.2 (−27.0, −5.3)**
Child	37.4 (24.7)	36.1 (21.1)	−1.3 (−7.5, 4.9)
Average pct kcal added sugars/day (%)			
Parent	10.10 (6.43)	7.85 (5.42)	−2.24 (−4.05, −0.44)*
Child	9.92 (5.65)	9.72 (4.87)	−0.20 (−1.61, 1.21)
Average HEI total score			
Parent	54.85 (12.72)	55.74 (13.01)	0.90 (−3.18, 4.98)
Child	56.88 (11.83)	58.31 (12.09)	1.43 (−1.76, 4.64)

*Paired t-test $p < 0.05$.
**Paired t-test $p < 0.01$.

Association between parent and child dietary changes

Decreases in parent total kcal were significantly associated with decreases in child total kcal in both unadjusted and adjusted models (p's < 0.05; Table 4). Despite minimal changes, on average, in parent and child vegetables and whole grains, there was a positive parent-child association for both vegetables and whole grains (p's < 0.05), though the association for vegetables

TABLE 3 Associations between parent dietary adherence and program engagement and dietary component changes.

	Parent diet change and days/week met dietary goal[a]		Parent diet change and total days of app usage[a]	
	B	***p***	***B***	***p***
Average kcal/day	−89.02	0.02	−2.75	0.12
Average pct fat/day (%)	−1.04	0.12	−0.06	0.05
Average total veg/day (cup)	0.05	0.45	0.004	0.16
Average total fruit/day (cup)	0.05	0.27	0.003	0.22
Average total protein/day (oz)	−0.29	0.21	−0.010	0.33
Average dairy/day (cup)	−0.09	0.16	−0.002	0.53
Average whole grains/day (oz)	−0.08	0.46	0.003	0.50
Average refined grains/day (oz)	−0.43	0.04	−0.013	0.20
Average added sugar/day (g)	−1.21	0.54	−0.041	0.65
Average pct kcal from added sugars/day (%)	0.06	0.88	0.002	0.90
Average HEI total score	1.36	0.13	0.07	0.10

[a]Regression of parent 6-month dietary component on total days of app usage or average days met dietary goal, controlling for number of children in the home, parent baseline BMI, and treatment group.

TABLE 4 Association between parent (IV) and child dietary component (DV) changes from baseline to 6 months and interaction by treatment group.

	Unadjusted model[a]		Adjusted model[b]		Interaction of parent diet by treatment group[c]	
Child dietary component	***B*** **(SE)**	**95% CI**	***B*** **(SE)**	**95% CI**	***B***	***p***
Average kcal/day	0.21 (0.10)*	0.005, 0.414	0.26 (0.11)*	0.048, 0.469	0.12	0.58
Average pct fat/day (%)	0.07 (0.09)	−0.102, 0.240	0.07 (0.09)	−0.111, 0.258	−0.24	0.22
Average total veg/day (cup)	0.20 (0.09)*	0.021, 0.374	0.18 (0.10)	−0.013, 0.367	−0.30	0.13
Average total fruit/day (cup)	0.18 (0.16)	−0.139, 0.507	0.10 (0.17)	−0.247, 0.450	−0.17	0.63
Average total protein/day (oz)	−0.09 (0.08)	−0.237, 0.065	−0.06 (0.08)	−0.219, 0.089	0.02	0.92
Average dairy/day (cup)	0.22 (0.17)	−0.127, 0.571	0.25 (0.18)	−0.110, 0.611	−0.11	0.75
Average whole grains/day (oz)	0.20 (0.10)*	0.004, 0.400	0.21 (0.10)*	0.015, 0.411	0.09	0.65
Average refined grains/day (oz)	0.39 (0.11)**	0.166, 0.623	0.41 (0.12)***	0.183, 0.646	0.11	0.63
Average added sugar/day (g)	0.15 (0.08)	−0.018, 0.322	0.16 (0.09)	−0.026, 0.342	−0.17	0.40
Average pct kcal from added sugars/day (%)	0.14 (0.11)	−0.075, 0.346	0.09 (0.11)	−0.132, 0.316	0.01	0.98
Average HEI total score	0.19 (0.11)	−0.031, 0.407	0.20 (0.11)	−0.033, 0.424	0.09	0.67

[a]Regression of child 6-month dietary component on parent 6-month dietary component, controlling for parent and child baseline values.
[b]Addition of covariates for child age, number of children in the home, parent baseline BMI, and treatment group.
[c]Addition of interaction term for treatment group by parent 6-month value of dietary component.
*Paired t-test $p < 0.05$.
***Paired t-test $p < 0.001$.

was attenuated to non-significance in the adjusted model ($p = 0.06$). Each additional 1 cup of vegetables among parents was associated with an increase of ∼0.2 cups of vegetables in children, and each additional ounce of parent whole grains was associated with an increase of 0.2 ounces of whole grains in children. In addition, there was a significant association between change in parent and child refined grains in unadjusted and adjusted models (p's < 0.01), such that a decrease of one ounce of parent refined grains was associated with a decrease of 0.40 ounces of refined grains in children. No parent-child dietary associations varied by treatment group.

Discussion

This study demonstrated that parents participating in a smartphone-based behavioral weight loss intervention had positive changes in several aspects of their diet, including total kcal, added sugars, and percent of kcal from added sugars. Children, on average, did not have significant changes in any dietary components. Despite that, there were some positive associations between changes in parent dietary intake and child dietary intake. Thus, while mean scores for some dietary components did not reveal significant changes in the same direction across the full sample of parents and children, some changes that parents made were associated with similar changes in their children. Specifically, child changes in total kcal, whole grains, and refined grains mirrored the changes made by the parent. The parent-child association for vegetable intake was significant in the unadjusted model but not after adjusting for several covariates. These are similar to the dietary components that have shown prior parent-child associations over time in consumption of grains, carbohydrates, and vegetables (30, 32, 33). In this study there was no parent-child association for dietary components such as protein, dairy, and fat, which is also commensurate with prior findings (33, 45).

Importantly, total kcal and HEI score represent overall changes in dietary intake, whereas the remaining variables represent changes in specific dietary components. This sample of children who, on average, do not have overweight or obesity, would be expected to have increases in caloric intake as they grow. The significant mean reduction in parent kcal over time in conjunction with the significant parent-child association in total kcal changes suggests that the children who had the lowest increases in kcal were those whose parents had greater decreases in kcal. Given that both the calorie and red food approaches were designed to target a reduction in caloric intake to achieve weight loss, these findings suggest that the dietary changes made by the parents to reduce their overall caloric intake impacted the overall dietary intake of their children, as well. This is commensurate with a prior study showing similarities in reductions in energy-dense foods among both parents and children (34). Interestingly, the diet quality as measured by the HEI score did not change in either parents or children in this sample. This suggests that the dietary changes parents made to lose weight may have included small changes across various dietary components, and that these changes were highly variable across parents (e.g., some parents may have chosen to eat more vegetables and less protein, whereas others may have chosen to eat more protein, less dairy, and make no changes in their vegetable intake). Children appeared to have improvements in the total HEI-2015 score, though this did not reach significance. The average HEI score at 6 months was 58.3, which is slightly higher than the national average HEI score of 54.5 for children 2–5 and 53.8 for children ages 6–11 (46), but well under the guidelines for a healthy diet.

Prior studies that have found associations between aspects of parent and child dietary intake have included intervention components specifically targeting the child, such as character-based intervention content and positive reinforcement using rewards (30–32). This is one of the first intervention studies to demonstrate that solely targeting parent dietary changes can also produce changes in child diet when parents successfully make changes in their own diet. Similarly, the parent-child associations did not differ by treatment group. The Standard group used detailed calorie tracking with few guidelines other than a calorie goal, while the Simplified group tracked only red foods and limited their high-calorie foods to 3–5 per day. This difference in type of dietary changes made and method of tracking did not have an impact on the dietary components that were similar among parent-child dyads, which suggests that parental improvements in diet, regardless of whether they focus on reducing total calories or just high-calorie red foods, have the potential to improve child dietary intake.

One of the aims of the present analysis was to understand more about how parent engagement and adherence in the program influenced parent diet, and subsequently child diet. This study was not powered to detect mediation effects, thus the analyses examined if parent engagement was associated with parent dietary changes. The finding of a significant association between average days per week meeting the daily dietary goal and total kcal is consistent with the program's goals and highlights the importance of self-monitoring daily dietary intake and meeting the calorie goal (or red food goal). It is possible that parent-targeted interventions can indirectly influence child dietary patterns through parents' own adherence to dietary self-monitoring, likely *via* changes in the home environment and meals prepared in the home, though this was not measured in this study. It is unclear why total days of engagement with the study app was associated with parent changes in percent of intake from fat and no other dietary components. Given that total kcal and total fat intake are sensitive to social desirability bias in dietary recalls, but that is less true for percent of fat from kcal (47), it is possible that percent fat as measured at baseline was higher and more accurately reported than other dietary variables, and thus appeared to have a greater reduction during the intervention.

A limitation to this study is its small sample size and short duration of 6 months, which limits the ability to detect long-term parent-child associations in dietary changes, and, given the large range in child age, to test differences by developmental stage of the child. Similarly, both the parent and child dietary outcomes were measured at 6 months, which precludes a conclusion that the changes the parents made in their eating behaviors had a prospective effect on changes in the children's eating behaviors. However, given that the intervention content was directly targeted to the parent, including daily dietary goals, the recommendation to self-monitor intake daily, and text messages and weekly feedback reinforcing the parent's dietary progress, it is not likely that parent-child dietary associations would occur in the other direction (i.e., child dietary changes occurred first and would subsequently impact parent dietary changes). An additional limitation is that this study was not designed to determine the mechanism of parent-child dietary changes. Based on prior research, the most likely mechanism is the changes that were made in the home environment (18, 20). Parents in both treatment groups had dietary goals designed to help them lose weight and likely made many changes in the food and beverages available in the home, which could impact the meals prepared and the food consumed by the child when they are in the home.

Overall, this study found several modest associations between program engagement and parent dietary changes, as well as some associations between parent and child dietary changes. These preliminary findings suggest the ability to improve child dietary behaviors without directly including them in an intervention or program, and the role of parents as role models in the home when focusing on their own health and wellness goals. Larger randomized trials are warranted that specifically test the effect of low-intensity, parent-targeted programs for promoting improvements in child dietary behaviors.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: The authors do not have permission to share raw study data due to requirements to protect the privacy of participants, in accordance with their informed consent (University of North Carolina at Chapel Hill IRB Study #17-3027). However, de-identified data related to this analysis may be made available upon reasonable request within 5 years of this publication. Requests to access these datasets should be directed to BN, bnezami@unc.edu.

Ethics statement

The studies involving human participants were reviewed and approved by the Institutional Review Board, University of North Carolina at Chapel Hill. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

BN and DT designed, implemented, and evaluated the original randomized trial. BN conceived the research question, conducted data analyses, and wrote the original draft. HW and DT provided feedback on the research question and analyses. All authors were involved in writing the paper and had final approval of the submitted and published versions.

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Conflict of interest

Author DT is a member of the Scientific Advisory Board for WW International and the Scientific Advisory Board for Wondr Health.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.972109/full#supplementary-material

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Perceptions of sugar-sweetened beverages among adolescents in North Carolina

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Introduction: Sugar-sweetened beverage (SSB) consumption among adolescents contributes to diet-related chronic disease including obesity, type 2 diabetes, and poor oral health.

Objective: To better understand adolescents' perceptions, attitudes, and consumption behaviors around SSBs by conducting virtual workshop discussions with adolescents in NC.

Materials and methods: Adolescents ages 11–17 in communities with a high proportion of Supplemental Nutrition Assistance Program (SNAP) eligible households were selected to participate in a series of virtual group workshops during summer 2021. A semi-structured discussion guide was used by a workshop facilitator. Workshop discussions centered around general health perceptions, SSB perceptions, and consumption behaviors. A thematic analysis was used to summarize knowledge, beliefs, attitudes, and perceptions around SSBs.

Results: Approximately 36 adolescents participated across four group workshops. Parents and caregivers influenced adolescents most when it came to making beverage choices. Positive SSB perceptions included liking the taste and the association with special times and social events. Negative opinions focused on associated health risks (diet-related chronic disease and poor oral health). Some adolescents acknowledged SSBs were not healthy but suggested they could be consumed occasionally. Very few participants mentioned any benefits from SSBs; those that mentioned benefits stated they provided energy, replaced electrolytes, and tasted good.

Conclusion: Findings provide several key insights that can contribute to the development of messages aimed at curbing SSB consumption among adolescents. For example, messages that focus on catching adolescents' attention and sharing short- and long-term health consequences of high SSB consumption resonated with adolescents, but because occasional SSB intake was not seen as consequential, messages that suggest abstinence from SSBs may not be helpful in reducing consumption.

KEYWORDS

adolescents, sugar-sweetened beverage, marketing, low-income, perceptions

Introduction

Approximately one in seven adolescents ages 10–17 in the United States suffers from obesity. In North Carolina, the childhood obesity rate is higher than the national average, 16.1% compared to 15.5%, respectively (1). Not only do these adolescents have health risks and complications during that developmental period, but they also have a higher likelihood of being obese adults and developing diet-related chronic disease such as type 2 diabetes, hypertension, and cardiovascular disease (2–6). They are also more likely to experience anxiety, depression, and low self-esteem, compounding the physical effects of diet-related disease (7, 8).

Sugar-sweetened beverage (SSB) intake among children is a leading contributor to obesity (9, 10) and strongly discouraged by leading child health organizations, including the Robert Wood Johnson Foundation's Healthy Eating Research Program (11). SSBs are the primary source of added sugar for adolescents and are the top contributor of empty calories in their diets (12). The National Health and Nutrition Examination Survey (NHANES) data analyses from 2003-2004 to 2013-2014 show that SSB consumption has declined in children, but these declines have been predominantly for higher-income, white children (13). SSB consumption among children is still disproportionate by racial and socioeconomic status with SSB intake higher among non-Hispanic blacks and low-income children (13, 14).

Poor dietary habits continue to be a public health problem in the United States, and parents and caregivers are the primary gatekeepers to adolescents' beverage consumption (15). Low-income adolescents who are most at risk for poor diets are often eligible for the Supplemental Nutrition Assistance Program Education (SNAP-Ed), the nutrition education component of the Supplemental Nutrition Assistance Program (SNAP) (16). The goal of SNAP-Ed is to improve the likelihood that persons eligible for the Supplemental Nutrition Assistance Program (SNAP) will make healthy food and lifestyle choices that prevent obesity (16).

North Carolina State University's (NCSU) SNAP-Ed program, Steps to Health, works to improve the diet and health of low-income North Carolinians (www.ncstepstohealth.org). Steps to Health sought to understand how North Carolina adolescents perceive and consume SSBs, and to gather data that could be used to develop a social marketing campaign that would appeal to adolescents and reduce SSB consumption. In 2020, an online survey of SNAP-eligible North Carolina adolescents ages 11–17 found that more than three-quarters of respondents (87%) reported drinking at least one SSB per day. Sodas (40%) and fruit flavored drinks (36%) were the most commonly consumed SSBs, and consumption patterns did not vary between younger (11–14 years old) and older (15–17 years old) adolescents (17). The survey also found that there was a strong association between the perceived value of SSBs and higher levels of consumption (17).

The purpose of this study was to better understand adolescents' attitudes and behaviors related to access, availability, and consumption of SSBs. A series of virtual workshops with low-income adolescents in North Carolina were conducted during the summer of 2021. In addition to general attitudes and behaviors related to SSBs, the workshops explored trusted sources of information about health and other topics, and opinions on specific types of SSB products (to gauge understanding, as well as motivators and barriers). This paper focuses specifically on the youth perceptions of SSBs.

Materials and methods

The study authors conducted a series of virtual group workshops to explore adolescents' perceptions, attitudes, and behaviors around SSBs and SSB messaging. These workshops were designed as modifications to traditional focus groups by adjusting the location (virtual), and gathering of participants (i.e., some groups took place with each participant in a different location and on an individual screen; some participants were able to gather into a single room) to accommodate restricted protocols due to the COVID-19 pandemic.

This type of group discussion is useful to obtain detailed information about personal and group perceptions because they can provide a broad range of information and offer the opportunity to seek clarification on potentially complex or nuanced questions (18). RTI International's Institutional Review Board (IRB) designated the research and materials as "Not Human Subjects Research" and therefore exempt from review.

Data collection

The research team's plans for the four workshop discussions were informed by research suggesting the appropriate number to suggest theme saturation in similar traditional focus groups (specifically, two to three moderated groups have been found to include at least 80% of themes; three to six groups will include 90% of themes) (19). NCSU worked with Family and Consumer Science (FCS) cooperative extension agents who deliver nutrition education for Steps to Health to recruit participants and assemble the virtual workshops. Middle and high school adolescents ages 11–17 in communities with a high proportion of SNAP eligible households were selected to participate. To ensure geographic diversity across the state, FCS agents recruited participants located in the three main regions of the state (western, central, and eastern North Carolina). Eligible adolescents were those who reported they were: (1) between the ages of 11 and 17; (2) lived in a SNAP-eligible household; (3) spoke English; and (4) had access (either individually or in a group) to a computer with the Zoom web conferencing program (20).

Before participating in the workshop discussion, parents gave their permission to have their child participate. Prior to the adolescents beginning the workshop, they provided their assent. Each workshop was conducted remotely on Zoom and was audio (but not video) recorded. To ensure privacy, a group-specific Zoom link was sent to participants or the FCS agent and a "waiting room" was enabled so that only those who the moderator admitted into the meeting were allowed to enter and participate in the workshop. To protect confidentiality, only first names were used in the discussion. Workshop discussions lasted approximately 60 min and were led by a trained moderator familiar with the research topic and a notetaker who observed and recorded detailed comments and non-verbal reactions.

To facilitate recruitment and maximize participation while considering limitations around in-person data collection and considering COVID-19 protocols, workshops were conducted using a flexible approach. This included relying on guidance from the FCS agent that recruited and assembled the groups, and the needs of adolescent participants. As a result, the workshops were conducted under two types of configurations. The first involved adolescents gathering in a single location watching the workshop facilitator and viewing stimuli on a single screen. For this configuration, the room of adolescents were not on video (the moderator could not see the youth). The FCS agent present with the adolescent participants in the room aided in facilitating the discussion. The second configuration had adolescent participants join *via* their own device (e.g., laptop or phone) with one participant per device. For this setup, adolescent participants joined from home or another location. Due to the funding source, adolescents were not compensated for participating in the group discussions.

Workshop discussion guide development and procedures

A semi-structured discussion guide was developed containing questions related to attitudes, behaviors, norms, and consumption of SSBs, as well as items related to information sources and perceptions of SSB advertising (Appendix A). Questions were modified and expanded based on results from a 2020 online survey of SNAP-eligible North Carolina adolescents ages 11–17. The phrasing of questions had already tested with youth regarding the perceived value of SSBs and general attitudes toward them (17). This discussion guide was pilot tested with one group of adolescents to ensure that questions could be easily understood and interpreted by potential participants. No changes to the discussion guide were made before using it during the formal workshop discussions. This paper focuses on questions in the guide that centered around: (1) general health perceptions, and (2) SSB perceptions and behaviors. These sections are listed in further detail below:

General healthy behaviors—perceptions and behaviors

Participants were asked a series of questions to orient them to the general topic of healthy behaviors. These questions also helped ground the workshop discussion by asking what comes to mind when adolescents hear certain key phrases, including "healthy eating" or a "healthy diet." Participants were then asked about how important "healthy eating" was (including avoiding unhealthy foods), and about who influences them when they make choices about what to eat or drink.

Sugar sweetened beverages—perceptions and behaviors

Participants were shown a series of six sets of images that depicted different categories, or types, of SSBs. Each stimuli set featured a group of images representing individual products (images were generically labeled to avoid brand associations outside of the product type). Stimuli sets included: (1) soda, (2) water, (3) energy drinks, (4) 100% fruit juice and milk, (5) sports drinks, and (6) fruit flavored beverages, sweetened teas, and lemonade (see Figure 1). After seeing each set of images, participants were asked to describe their first reactions, thoughts, feelings, and opinions for each of the image sets verbally or *via* the "chat" feature in Zoom. Participants were then asked to describe their overall reaction to the phrases "sugar sweetened beverages" and "sugary drinks" and the products that the phrases represented. Adolescent participants provided details regarding situations when they chose to drink SSBs, and about parental and peer influences in those decisions. They also described health risks associated with drinking SSBs.

Analysis

Workshop discussions were audio recorded and transcribed. Detailed notes (participant comments and non-verbal reactions, including nodding or raising hands to indicate agreement with a point), audio transcriptions, and the Zoom chat transcript were organized into a meta-matrix by moderator question. The study authors employed an inductive approach to develop a coding scheme that allowed for thematically summarizing participants' responses. Coding used the comprehensive data (notes, audio transcripts, chat records) in the matrix and were organized around knowledge, beliefs, attitudes, and perceptions around SSBs and advertising perceptions and preferences and allowed for focusing on the interpretation and meaning of the

FIGURE 1
Sample sugar sweetened beverage stimuli.

themes (21–23). The moderators (SR and KG) independently reviewed the transcripts and discussed participants' responses to questions. The two moderators (SR and KG) compared themes and reconciled any discrepancies through discussions. After discussing the participant responses, they (SR and KG) identified themes based on similar and related topics (23). Key findings are summarized below, and illustrative quotes are included to highlight participant comments to give context.

Results

A total of four virtual workshop discussions were conducted with adolescents during the summer of 2021 (see Table 1). Two of the workshops were held in a classroom with adolescent participants viewing a large screen showing the facilitator. The other two used the format of adolescents participating from home on their individual device *via* Zoom. Approximately 36 adolescents ages 11–17 participated across the four discussions. Due to the nature of the virtual setup, during one of the workshops, facilitators were unable to see all participants who gathered in a single location through the video. The onsite FCS agent who helped facilitate reported the number of participants; however, some left early and therefore the number of participants who participated in that discussion may not be exact. Virtual workshops were held in Yadkin, Richmond, Wake, and Northampton counties in North Carolina.

Perceptions and behaviors around healthy eating or a healthy diet

When participants were asked What do you think of when you think about "healthy eating" or a "healthy diet" there was a general consensus across the adolescents that healthy eating or a healthy diet included consuming fruit, vegetables, grains, dairy, and protein. One participant mentioned healthy (lean) meat and another mentioned following *MyPlate* guidance based off the 2020 Dietary Guidelines for Americans (24). One participant commented, "*From a high school point of view, [healthy eating] is a big thing…like body image, us being healthy—a lot of girls are focusing on it.*" [Female, Group 1]. Only three participants independently mentioned beverages when asked about a healthy diet: one participant noted that a healthy diet includes drinking more water while the two other participants mentioned avoiding soda. Adolescent participants also mentioned avoiding pizza, candy, fast food, processed/pre-made food, chips, cereal, and ice-cream.

In response to the question, "Who or what influences you when it comes to making choices about what you eat or drink?" most adolescent participants stated that their parents/caregivers influenced them: "*My parents influence me the most. Friends*

TABLE 1 Workshop participants, locations, and dates.

Group Number	Number of Participants	Location	Group Type	Date
1	10	Yadkin county	Home with individual devices	9/07/2021
2	15*	Richmond county	Classroom with large screen	9/08/2021
3	3	Wake county	Classroom with large screen	9/14/2021
4	8	Northampton county	Home with individual devices	9/14/2021

*Because moderators were not able to see participants who were gathered in a single location, the number of participants who completed the Group 2 discussion may not be exact.

don't have a big influence." [Male, Group 4]. A couple of participants mentioned friends as influential: "*[My friends] influence me because I know a lot of my drinks drink a lot of water, so I just started drinking more water sometimes*." [Male, Group 4]. One participant noted that she sometimes ate food or beverages at her friends' houses that she would not usually consume at home: "*Some things I eat at my friends' houses are different than what I eat at home*." [Female, Group 1].

Perceptions and behaviors around sugar sweetened beverages

The workshop facilitator shared a series of six sets of images that depicted different categories, or types, of SSBs. Stimuli sets included: (1) soda, (2) water, (3) energy drinks, (4) 100% fruit juice and milk, (5) sports drinks, and (6) fruit flavored beverages, sweetened teas, and lemonade (see Figure 1). After seeing each set of images, participants were asked how they would "label" the type of beverage using a word or phrase (i.e., identify the category to which they belonged). There was general consensus across all workshops around the categorization of each of the SSB image sets, with participants recognizing the connection between the individual products in each set and offering similar language to label them. This was followed up by the moderator asking the participants to consider their experiences with these beverages (positive or negative opinions), situations when they might drink them, and any other opinions regarding the SSB type. We describe adolescent participant response to each of the six SSB categories below.

Soda image sets

When adolescents were shown the soda image set (which included soft drinks and other sugar-sweetened carbonated drinks), participants associated the images with words and phrases including "fizzy, bubbly, artificial flavors, sugar, very sweet, sticky, cold, tasty." Adolescents shared that the soda image made them think about situations when they would drink them, such as church potlucks and cook-outs. Other participants said that the images prompted thoughts related to the immediate effects of drinking them, including feeling hyper (due to caffeine) or energized, or feeling that they fill you up so you do not each as much. One participant commented, "*[Soda] makes me think of being hyper and caffeinated because my parents always tell me if I drink too much soda that I will get hyper*." [Male, Group 1]. In addition, several participants mentioned health risks associated with drinking soda (e.g., causing pimples, diabetes, being unhealthy): "*[Soda] tastes good, but it's not always good for you to drink all the time*." [Female, Group 4].

When asked whether they had a positive, negative, or neutral opinion of sodas, among those participants who responded to this question, 10 participants had only positive opinions of sodas, 10 participants had only negative opinions, and 12 participants had both positive and negative opinions. Positive opinions were centered on liking the taste and thinking of special times when they drink them. Negative opinions were focused on associated health risks of consuming too much sugar. Some participants acknowledged that sodas were not good for them, but suggested they were okay to drink in moderation.

Water image sets

After showing adolescents the water image set (which included water, mineral water, and water with fresh fruit), participants associated the images with words and phrases including "cold, ice, refreshing, crisp, summer refresher, no sugar, healthy, beneficial".

When adolescent participants were asked to share their initial thoughts about the water image set, they said that the images made them think about health. More specifically participants discussed how water helps keep them alive and hydrated, is beneficial for their skin (relating water consumption to acne prevention), and is necessary for the human to function: One participant made this connection by noting a perception that the body already consists mostly of water: "*You can drink [water] all the time…it doesn't hurt your body…your body is mostly water anyway so just adding water helps it*." [Male, Group 4]. Participants also mentioned that the water image set made them think about "taste", such as "tasty with ice" or having no sugar in it and not having any taste. When asked about situations when they would drink water, most adolescent participants mentioned water was best after playing or exercising outside when the weather is hot. Additionally, some adolescents pointed out that they could drink water all the time, as opposed to SSBs.

Among participants who responded when asked about their positive or negative opinions of water, nearly all had positive opinions of water and only two adolescents expressed some negative opinions. Positive reactions were focused on the health benefits of drinking water, water's refreshing qualities and its taste. The two participants who included negative comments suggested that some water sources (such as free tap water) may not be clean or safe to drink.

Energy drinks image sets

After being presented with the energy drink image set, participants associated the images with words and phrases including, "unhealthy, chemicals, espresso shots, sugary, bad for you, [brand name] energy drink, hyper, and energetic." Of these associations, the most frequent response among adolescent participants was "hyper." Some participants said that the images of energy drinks made them think about their wide availability. As one participant said, "*Everyone at school drinks [energy drinks] because they are in the vending machines.*" [Female, Group 1]). Additionally, a few participants mentioned examples of advertising that suggests the type of person who drinks them (specifically race car drivers). Others discussed the negative health effects from consuming too much of them: "*I heard one time that someone drank too many energy drinks and they died from that.*" [Female, Group 4].

Among participants who responded when asked about their positive or negative opinions of energy drinks, no participants had only positive opinions of energy drinks, nine participants had only negative opinions, and four participants had both positive and negative opinions. Negative attitudes focused on the associated health risks, particularly related to the impact of high levels of caffeine in the body. Those who had both positive and negative reactions acknowledged that they believed they were unhealthy, but that they liked the "boost" that the caffeine gave them, as it helped them get energy for staying engaged in school or other afterschool activities. As one participant stated, "*I know [energy drinks] are bad for you but sometimes I like to drink them when I'm tired.*" [Female, Group 1].

100% fruit juice and milk image sets

When adolescents were presented with the 100% fruit juice and milk image set (which included orange juice, apple juice, and milk), adolescent participants said that words and phrases associated with this image set (participants called them "*breakfast drinks*") included: "breakfast, fruit, healthy, and strong." Adolescent participants said that the image of these "breakfast drinks" made them think about the taste and health related topics. When discussing taste, participants were specific: one participant commented that orange juice was too sour, and another said they didn't like the pulp in 100% orange juice. Regarding health-related topics, several participants mentioned that some people are lactose intolerant, while others stated that milk is good for their bones: "*[Fruit juice and milk] are healthy drinks and milk is good for the bones.*" [Female, Group 4]. When asked about when they would consume "breakfast drinks" participants said that they would have milk with cereal and drink the other juices mostly in the morning. As one male participant commented, "*I think [orange juice] is really good breakfast thing; you wake up and get some OJ. I eat a lot of cereal, so I like milk.*" [Male, Group 3]. Several participants simply noted that 100% fruit juice and milk were "healthy".

Among those who responded when asked about positive and negative opinions of the image set, seven adolescents had only positive opinions, and two had both positive and negative opinions. Positive reactions included the health benefits and taste, while the negative reactions were centered on disliking the taste (mentioned above).

Sports drinks image sets

After showing adolescents the sports drink image set (which included sports drinks, bottles that mimicked a brand-name product, electrolyte drinks, and other energizing drinks), participants said that words and phrases associated with those beverages included, "thirst quenching, healthy, sports recovery, drinks for athletes or during physical activity, sweat, salt, and summer party drink." When asked what they thought about sports drinks after seeing the image set, adolescent participants said they thought about specific sports or activities when they drink them (such as soccer, softball, basketball, volleyball, and football; as well "field days" at school). Some participants remembered drinking a brand name sports drink when they were sick or during the summer. Several participants noted that it could be used to replenish electrolytes and salt in the body. Lastly, specific sport drink flavors were mentioned.

Among adolescents who responded to questions about negative and positive opinions about sports drinks, four adolescents had only positive opinions and three adolescents had positive and negative opinions. Some of those who had only positive reactions cited the potential health benefits: "*[Sports drinks] helps replenish electrolytes and salt.*" [Female, Group 1]. Other participants suggested that they felt the drinks were refreshing. Those who had both positive and negative reactions liked the hydration benefits for some physical activities [as one participant noted: "*We have (sports drinks) during/after sports so you can get hydrated after your game because you might not have* *had as much to drink during the game."* (Female Group 1)], but did not like the tasted or also acknowledged that they contained added sugar.

Fruit drinks, teas, and lemonade image sets

When adolescents were presented the fruit drinks image set (which included fruit drinks, sweetened tea, and lemonade), adolescents said they associated fruit drinks with words and phrases such as, "sweet, sugary, artificial, summer camp, unhealthy, drinks for kids, tasty, hyper, and loaded with sugar." Adolescent participants said that the images made them think about the about taste, situations where they might consume them, health risks, and specific ingredients or brand names of fruit juices. In terms of taste, some participants felt the fruit drinks tasted "artificial" but were still "tasty" or a desirable beverage option. Places or situations where adolescent drink fruit drinks included celebrations (especially with young children) or cookouts. One participant mentioned a perceived health risk that fruit drinks can negatively impact kidney functioning. Finally, adolescent participants generally noted mentioned that sugar was a main ingredient in fruit drinks and other participants mentioned specific brands neither negatively or positively.

Among adolescent participants who responded to the question about positive and negative opinions about fruit drinks, a few had both positive and negative opinions. Those who had negative opinions cited the health risks associated with consuming too much sugar: "*They are not very healthy and loaded with lots of sugar*." [Female, Group 4]. Those with positive reactions noted, *"[Fruit drinks] are nostalgic but unhealthy"* [Female, Group 1] when talking about them in relation to past celebrations or other social gatherings.

Conclusions

This study provides several key insights regarding adolescents' perceptions, attitudes, and consumption behaviors around SSBs in NC. First, research on the correlation between low-income adolescents and health literacy is mixed. This study shows that low-income adolescents participating in our workshop discussions had fairly high health literacy regarding the harms of consuming SSBs. For the purposes of this discussion, health literacy "is the extent to which individuals attain, manage, and understand health information and apply that information in health decision-making" (25). In a 2018 systematic review of adolescent health literacy and health behaviors (26), among five studies that examined the relationship between income and health literacy, four studies found that having lower incomes was associated with lower health literacy, while only one found no statistically significant relationship between the two (27). However, since adolescents in this study were recruited from SNAP-Ed classes, this may have increased their health literacy as the curriculum focuses on promoting the consumption of beverages low in added sugar, and the negative health impacts of consuming large amounts of SSBs.

Additionally, adolescent responses revealed that they viewed their parents/caregivers as role models in terms of what beverages to drink. Other research supports that children and adolescents look to their parents/caregivers for guidance and often mirror or mimic their health behaviors (28). This is consistent with a 2012 study that showed parent support for healthy beverage consumption was associated with reduced SSB consumption among 541 children between the ages of 5 and 8 years old (28). Additionally, since parents/caregivers are more likely to be responsible for stocking foods and beverages at home, if they purchase SSBs, children are more likely to consume them (29). Therefore, raising parents' and caregivers' awareness of the impacts that their own health behaviors have on their children continues to be a promising public health strategy to curb SSB consumption among adolescents.

Strategies for raising awareness among parents and caregivers can take many forms, including through social marketing—the use of consumer marketing techniques (e.g., audience segmentation, advertising campaigns) to promote voluntary behavior change to achieve positive population-level effects (30). Findings from this study will be useful in informing the development of a social marketing campaign aimed at reducing SSB consumption among adolescents. For example, messages that focus on catching adolescents' attention and sharing both short- and long-term health consequences of high SSB consumption may resonate with adolescents. However, because occasional SSB intake was not seen as consequential among workshop participants (e.g., consuming soda or sweet tea during special occasions), messages that suggest abstinence from SSBs may not be helpful in reducing consumption.

Previous research on social marketing campaigns and interventions implemented in the United States and Europe have targeted adolescent SSB consumption with positive effects (31–33). For example, the evaluation of a campaign in the Netherlands that promoted the consumption of water over SSBs directly to adolescents found that the intervention was related to an overall reduction in SSB consumption (31). Communication campaigns targeting the influence of parents have had similar results (32, 33). For example, exposure to a city-wide media campaign in Philadelphia that targeted parents with a child between the ages of 3–16 years to reduce SSB consumption was significantly associated with the parents' intent to substitute non–sugary drinks for SSBs for their children (33). However, there are still gaps in our understanding of how adolescents understand and receive SSB-specific social marketing campaign messages and materials, particularly when media messages are intended to reach them directly.

Like all research, this study had several limitations. Due to protocols for research during the COVID-19 pandemic, the workshops were virtual, which required a hybrid set-up of all adolescents watching one large screen or adolescents being on their individual screens. Some adolescents did not have their cameras enabled, so it was difficult to gauge some non-verbal responses or cues to the moderator's questions. Because of this adaptation, the workshops were not traditional focus groups; however, the consistent application of a single discussion guide, stimuli presentation, and coding scheme allowed us to summarize findings across all group discussions. The virtual environment may have also had some advantages over in person group research, including facilitating more participant diversity by reducing some barriers (e.g., transportation, time) and encouraging contributions to the discussion, and has been used successfully to collect information with variety of audiences, including adolescents (34).

Additionally, due to the small sample size and restrictive geographic location (adolescents had to live in NC), results may not be generalizable to adolescent populations in other states. Lastly, since adolescents were already enrolled in SNAP-Education classes, they may have had higher health literacy regarding the harms of SSBs, which could have influenced their responses in the discussion. In addition, as a qualitative study with a self-selected group of participants, there are limitations in the generalizability of findings.

Each group included a facilitator who led the discussion and a dedicated notetaker, who captured detailed notes including verbal comments and other observations about the group. Group discussions were also audio recorded and transcribed. The combination of these data allowed for a comprehensive review of participants' responses and reactions. The use of thematic analysis based off the combination of detailed notes that captured non-verbal responses (e.g., raised hands, nodding, and other indicators of agreement where possible), audio transcriptions and chat transcripts from each of the workshops is a strength in that it focuses on the interpretation and meaning of themes (22). Lastly, both of the workshop facilitators independently reviewed the data and coded responses. Discrepancies around interpretation of themes were discussed until agreement was reached. During this process, they identified themes based on similar and related topics to reach a consensus.

This study reveals several important themes, including that adolescents have both positive and negative opinions regarding six different types of beverages: (1) soda, (2) water, (3) energy drinks, (4) 100% fruit juice and milk, (5) sports drinks, and (6) fruit flavored beverages, sweetened teas, and lemonade. The information we have learned about adolescent perceptions of these drinks could help contribute to the development of messages aimed at reducing SSB consumption. Future research should continue to examine adolescent perceptions, attitudes, and consumption behaviors around SSBs. Additionally, raising awareness among parents/caregivers regarding the level of influence on their children is an important factor to consider. SSB intake among adolescents is a leading contributor to obesity and other diet-related chronic diseases. Researchers and public health practitioners should continue to examine strategies and interventions aimed at decreasing SSB consumption.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by RTI International's Institutional Review Board. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

LH-M, SR, and KG: conceptualization and methodology, writing—review and editing, and writing—original draft preparation. SR and KG: analysis and investigation. LH-M: funding acquisition. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

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Bidirectional associations between maternal controlling feeding and food responsiveness during infancy

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Parental controlling feeding styles and practices have been associated with greater food-approaching appetitive behaviors (i.e., food responsiveness) linked to childhood obesity. Recent longitudinal research suggests that this relationship may be reciprocal such that controlling feeding predicts child appetite and vice versa. However, to date no studies have considered these associations during infancy. The current study investigates prospective bidirectional associations between controlling feeding (restriction, pressure, and food to soothe) and infant food responsiveness. Mothers ($N = 176$) reported their controlling feeding and their infant's food responsiveness at infant age 2, 6, and 14 months. A 3-wave cross-lagged panel model was used to test the effect of controlling feeding at an earlier time point on infant food responsiveness at a later time point, and vice versa. Maternal controlling feeding and infant food responsiveness showed moderate stability across infancy. Net of covariates, we observed parent-driven prospective relations between pressuring feeding styles and food to soothe with infant food responsiveness. Pressuring to finish was a significant predictor of increases in food responsiveness from 2 to 6 months ($p = 0.004$) and pressuring with cereal was a significant predictor of increases in food responsiveness from 6 to 14 months ($p = 0.02$). Greater use of situational food to soothe was marginally associated with higher food responsiveness from 2 to 6 months ($p = 0.07$) and 6 to 14 months ($p = 0.06$). Prospective associations between restrictive feeding styles and infant food responsiveness were not observed. Findings point to pressuring feeding styles and food to soothe as potential early life intervention targets to prevent increases in food responsiveness in infancy. Longitudinal research with follow-up in the toddler and preschool years are needed to understand how these associations unfold over time and whether child-driven effects of food responsiveness become apparent as children get older.

KEYWORDS

controlling feeding styles, food responsiveness, infancy, bidirectional effects, cross-lagged analysis

Introduction

Food responsiveness, or a child's tendency to overeat, is an important appetitive behavior indicative of food approach that predicts increased childhood obesity risk. Food responsiveness describes an infant's level of feeding demandingness, responsiveness to milk and feeding cues, and propensity to eat more than provided (1). Individual differences in food responsiveness are observable from early infancy, and elevated food responsiveness has been associated with higher infant weight and rapid infant weight gain (2–4). Food responsiveness is in part genetically determined (5, 6). Although prior studies have shown increases in average food responsiveness scores from 3 months to 15 months (2) and 4 to 11 years (7), significant positive correlations between time points suggest some stability in food responsiveness over time (2, 7). Nevertheless, the expression of this behavioral phenotype depends on interactions with environmental influences (8, 9). Thus, there is great interest in identifying modifiable, early life factors in children's immediate environment that impact food responsiveness.

Parental feeding is believed to be one of the earliest modifiable determinants of children's appetitive behaviors (10) and may contribute to the intergenerational transmission of obesity (11). Feeding practices and styles refer to the attitudes and behaviors surrounding how parents approach the management of what, when, and how much children eat (12, 13). Specifically, controlling feeding such as restricting intake, pressuring to eat, and non-nutritive feeding practices (i.e., feeding to soothe, the use of food as a reward) disregard children's hunger and satiety cues, which over time, can encourage children to eat for reasons besides hunger (e.g., to regulate emotions, in response to visual feeding cues) (12, 14). As such, controlling feeding has been implicated in child obesity risk via its impact on increased food-approaching appetitive behaviors such as food responsiveness.

A substantial body of literature has examined associations between controlling feeding and child weight status. Positive associations between parents' use of food to soothe infant distress, a commonly used controlling feeding practice in infancy, and infant weight have been reported in both cross-sectional and longitudinal studies (15–17). Although studies among infants and young children have generally shown that restrictive feeding is associated with higher child weight status and pressure to eat is associated with lower child weight status, many of these findings come from cross-sectional research and the direction of effects remain unclear (18). For example, do children gain weight because of parents' restriction that may unintentionally prompt children to eat more or do parents restrict intake out of concern that their child is overweight? Given children's appetitive behaviors may mediate the link between parental feeding and child weight (12), controlling feeding is likely influenced by child weight status as well as their appetitive tendencies (19).

Bidirectional associations between parental feeding and child weight have been examined (20–25) and research has increasingly focused on potential bidirectional associations between feeding and appetitive behaviors. A recent systematic review and meta-analysis that included 14 prospective longitudinal studies examining relations between parental controlling feeding and child appetitive behaviors revealed two significant pooled effects (26): higher child food responsiveness predicted increases in restrictive as well as instrumental feeding (i.e., the use of food as a reward). In line with these results, a recent study showed that higher child food responsiveness at 4–5 years predicted an authoritarian feeding style marked by high levels of parental control when children were aged 7–9 years (27). Although pooled analyses were not conducted for longitudinal associations between pressure to eat and food responsiveness or between emotional feeding and food responsiveness in the aforementioned systematic review due to a limited number of studies, 3 of the 14 prospective studies reported significant longitudinal effects. One study found a bidirectional relationship between pressure to eat and food responsiveness such that higher pressure to eat at age 4 predicted lower food responsiveness at age 7 and vice versa (28). In contrast, a study conducted with children 1.5–2.5 years old showed that encouragement to eat (e.g., prompting, praise for eating) was positively associated with children's tendency to overeat 1 year later (29). Two studies reported parent-driven effects of emotional feeding (a measure that encompasses feeding to soothe) on increased child food responsiveness across two time points over a one-year period among children aged 1.5–2.5 years at baseline (29) and across four time points spanning a 3-year period (aged 2–4 years at baseline, 1, 2, and 3 years later) (30).

Taken together, these findings point to the complex and likely bidirectional nature of parent-child feeding interactions, yet longitudinal studies are currently needed, particularly those that formally test bidirectional effects controlling for prior levels of feeding and food responsiveness. Previous longitudinal research examining controlling feeding and food responsiveness has primarily been conducted among children 2 years of age and older. To our knowledge, no studies to date have been conducted among children across the 1st year of life. Given rapid infant weight gain, especially during early infancy (0–6 months), is associated with later obesity and related comorbidities (31, 32), it essential to understand how obesogenic parent feeding and child appetitive behaviors influence one another during this sensitive period of development.

The purpose of the current study is to prospectively examine bidirectional associations between parental controlling feeding (restriction, pressure, and food to soothe) and infant food responsiveness in a community sample of mother-infant dyads using a 3-wave cross-lagged panel model. Based on previous research, we hypothesized that: (1) greater maternal endorsement of a pressuring feeding style and greater use of food to soothe predict increases in infant food responsiveness, and (2) infant food responsiveness predicts increases in maternal restrictive feeding over time.

Methods

Participants

Pregnant women were recruited in Guilford County, North Carolina to participate in the Infant Growth and Development Study (iGrow), an ongoing longitudinal study examining prenatal and early life predictors of childhood obesity risk. Recruitment methods included childbirth education classes, Special Supplemental Nutrition Program for Women, Infants and Children (WIC) breastfeeding classes, flyers advertised in OB/GYN clinics, and social media. Eligibility criteria consisted of (1) maternal age ≥18 years, (2) expecting a singleton, (3) written English comprehension, and (4) plans to remain in the region for at least 3 years. Participants in the current study included mother-infant dyads from iGrow cohort 1 ($N = 176$).

Procedures

During the 3rd trimester of pregnancy, mothers provided written consent and completed online questionnaires using Qualtrics, a popular survey platform. Approximately 1 week after infants' due dates, we obtained infant birth details via phone interviews and confirmed mother's eligibility. Mothers completed online questionnaires again when infants were ∼2, 6, and 14 months old. Women were compensated $50 for the prenatal visit, $70 for the 2-month visit, $80 for the 6-month visit, and $90 for the 14-month visit. Data collection for cohort 1 took place between February 2019 and October 2020. This study was approved by the university's Institutional Review Board (protocol #18-0198).

Measures

Maternal controlling feeding

The Infant Feeding Styles Questionnaire (IFSQ) was used to measure mother's controlling feeding styles (33). The IFSQ was originally validated in a low-income sample of Black mothers (33) but has been successfully used with mothers representing a diverse range of sociodemographic characteristics (34–36). To reduce the length of the entire questionnaire battery and thus participant burden, several items were omitted across multiple individual measures. For the IFSQ specifically, mothers completed a subset of 79 of the 83 IFSQ items, which yielded 13 subscales. Mothers rated their behaviors and beliefs around feeding an infant on a 5-point scale. Response options for behavior items ranged from never to always and response options for belief items ranged from disagree to agree. For the current study, we focused on four subscales that are considered controlling: pressuring-finish, pressuring-cereal, restrictive-amount, and restrictive-diet quality. The IFSQ has 20 behavioral items related to feeding solid foods for infants ≥6 months. Consequently, the pressuring-finish ("insist re-try new food refused at same meal"; "praise after each bite to encourage finishing") and restrictive-diet quality ("I let child eat fast food"; I let child eat junk food") subscales have two more items at 6 months and 14 months than at 2 months. One of the removed items was from the pressuring-finish subscale ("I try to get my baby to finish his/her breastmilk or formula) and another was from the pressuring-cereal subscale ("I give/gave my baby cereal in a bottle"). Items were averaged to create a summary score for each subscale at each time point with higher scores indicating greater endorsement of the given feeding behavior/belief. The subscales used in the current study had adequate internal consistency reliability: pressuring-finish (five items at 2 months, $\alpha = 0.69$; seven items at 6 months and 14 months $\alpha = 0.70–0.76$), pressuring-cereal (four items at all time points, $\alpha = 0.78–0.80$), restriction-amount (5 items at all time points, $\alpha = 0.71–0.78$), and restriction diet quality (five items at 2 months, $\alpha = 0.74$; seven items at 6 months and 14 months, $\alpha = 0.74–0.84$).

We used the Food to Soothe Scale (15) to measure the controlling feeding practice feeding to soothe. Mothers completed the 6-item situational subscale (e.g., use food to soothe baby in the grocery store, while in the car) and the 3-item state-based subscale (e.g., when you are stressed, tired, nothing else works). Mothers rated their likelihood of using food to soothe for each item on a 5-point scale (never to always) The 6 situational items were averaged to create a summary score at each time point ($\alpha = 0.76–0.81$) as were the 3 state-based items ($\alpha = 0.76–0.80$).

Infant food responsiveness

The 6-item food responsiveness subscale from the Baby Eating Behavior Questionnaire (BEBQ) (1) was used to assess infant food responsiveness at each postnatal wave. The BEBQ, although originally validated as a retrospective measure of infant appetite focused on the period of exclusive milk feeding (breast or bottle) (1), is commonly used to evaluate infant appetite across the 1st year (4, 37, 38). Mothers rated the extent to which their infant exhibited behaviors that reflect increased feeding demandingness and hunger ("My baby frequently wants more milk than I have given him/her"; "If given the chance, my baby would always be feeding") on a 5-point scale (never to always), with higher scores indicating higher infant food responsiveness.

A mean score was calculated at each time point (α = 0.80 at all waves).

Demographic characteristics and covariates

Mothers reported their age, race/ethnicity, educational attainment, individuals residing in the home, income, pre-pregnancy weight and due date prenatally. We calculated an income-to-needs ratio by dividing total annual household income by its corresponding poverty threshold determined by the year in which income is earned and the total number of household members. We used the Poverty Thresholds for 2018 and 2019 published in U. S. Census Reports (39). At a prenatal laboratory visit, trained research staff measured mother's height in duplicate and pre-pregnancy Body Mass Index (BMI; kilograms/m^2) was calculated using measured height and self-reported pre-pregnancy weight. Approximately 1 week after infant's due date, mothers reported infant sex, birth weight, and infant birth date, which was used to calculate gestational age. At each wave, mothers provided detailed feeding information using a modified version the Infant Feeding Practices Questionnaire Study II (40). Mothers reported the number of feeds that were breastmilk or formula over the past 7 days. At 2 and 6 months, the percentage of feeds as breastmilk was used to categorize infants as exclusively breastmilk fed, exclusive formula fed, or mixed fed (combination of breastmilk and formula). In addition, because all infants had been introduced to solid foods (e.g., complementary feeding) by 14 months, infants were categorized as breastfed (1 = any breastmilk) or not breastfed (0 = no breastmilk) at all three time points.

Statistical analysis

Preliminary analyses were conducted using SPSS Version 27 (IBM, Chicago, IL) and univariate statistics were used to describe the sample. Cross-lagged path models were conducted using AMOS Version 27 (IBM, Chicago, IL) to examine associations between maternal controlling feeding and infant food responsiveness at infant age 2, 6, and 14 months. Separate models were conducted for each controlling feeding subscale (i.e., pressure-finish, pressure-cereal, restrictive-amount, restrictive-diet quality, situational food to soothe, and state-based food to soothe). Time invariant covariates collected prenatally (i.e., maternal age, race/ethnicity, measures of socioeconomic status, pre-pregnancy BMI) and infant weight-for-age *z*-score at birth were adjusted for at the first time point. We also examined time invariant covariates in relation to outcome variables at later time points. However, given the small sample size, and for parsimony, if a time invariant covariate was not significantly associated with the outcome at that time point, the path was removed from the model. Covariates that were time varying, which included exact infant age and breastfeeding status at each time point, were adjusted for at their respective time point (e.g., infant age at 2 months was specified on infant food responsiveness and controlling feeding at 2 months). Cross-lagged path models were used to examine the bidirectional associations between controlling feeding and infant food responsiveness across infancy (Figure 1). The use of a cross-lagged analytic model was an ideal design given this type of analysis allows for the simultaneous evaluation of three types of associations: stability coefficients between repeated measures over time (e.g., pressuring feeding at 2 months with pressuring feeding at 6 months), concurrent correlations between controlling feeding and food responsiveness at each time point, and cross-lagged associations that estimate the prospective effect of controlling feeding at an earlier time point with food responsiveness at a later time point, and vice versa. Full information maximum likelihood was used to handle missing data (41). Because small prospective effects between controlling feeding and child appetitive behaviors have been previously reported (26), we interpreted our findings considering both statistically significant ($p < 0.05$) and marginally ($p < 0.10$) significant results.

Results

Sample characteristics

Table 1 displays the characteristics of the sample. The mean (*SD*) age of mothers was 29.10 (5.92) years, 54% of mothers identified as non-White, 22% of mothers had a high school education or less, and 56% had overweight or obesity pre-pregnancy. Approximately half of infants were female. Most infants were full-term and had a normal birth weight according to their gestational age. At 2 months, 6 months, and 14 months, 73.5%, 55.9%, and 31.8% of infants were breastfeeding (i.e., fed any breastmilk).

Concurrent and prospective associations between maternal controlling feeding and infant food responsiveness

Table 2 shows all path coefficients from the cross-lagged analysis depicted in Figure 1. Maternal controlling feeding styles and food to soothe were relatively stable across infancy. In general, there was greater stability in maternal feeding from 6 months to 14 months (β = 0.52–0.67) than from 2 months to 6 months (β = 0.44–0.60). Infant food responsiveness also demonstrated significant stability across infancy (2 to 6 months: β = 0.33; 6 to 14 months: β = 0.27).

In the separate cross-lagged models examining associations between maternal controlling feeding and infant food

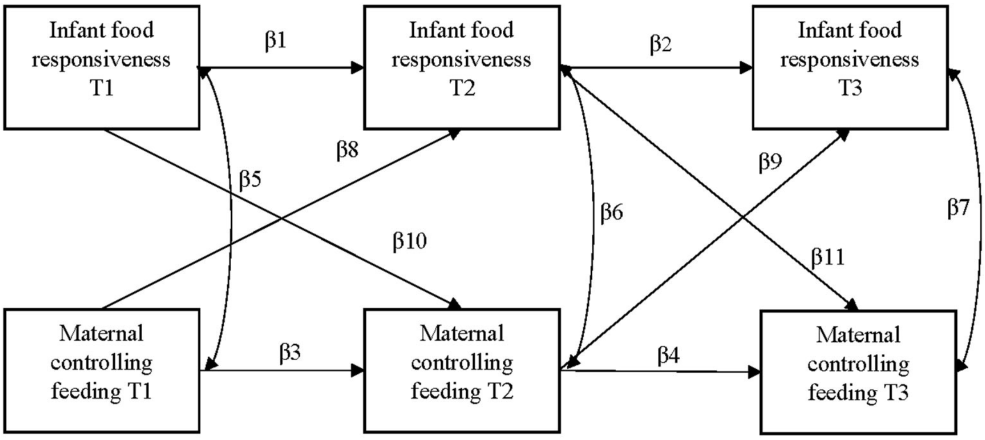

FIGURE 1
Conceptual model for longitudinal associations between maternal controlling feeding and infant food responsiveness. T1 = infant age 2 months, T2 = infant age 6 months, T3 = infant age 14 months.

responsiveness, we observed several concurrent associations. At 2 months, greater pressuring to finish and state-based food to soothe (i.e., when mothers are stressed, tired, nothing else works) were both significantly associated with higher infant food responsiveness. Restrictive amount and situational food to soothe (e.g., use food to soothe baby in the grocery store, while in the car) were also marginally positively associated with higher food responsiveness ($p < 0.10$). At 6 months, greater pressuring with cereal and restrictive amount were both significantly associated with higher infant food responsiveness. At 14 months, pressuring to finish was marginally positively associated with food responsiveness and restrictive diet quality was marginally negatively associated with food responsiveness ($p < 0.10$).

In the two models examining pressuring feeding styles, results showed parent-driven cross-lagged associations with infant food responsiveness. Greater pressuring to finish was a significant predictor of increases in infant food responsiveness from 2 months to 6 months ($\beta = 0.23$, $p = 0.004$, 95% CI = 0.07-0.38) and was marginally associated with higher infant food responsiveness from 6 to 14 months ($\beta = 0.16$, $p = 0.06$, 95% CI = −0.01–0.33). Greater pressuring with cereal was a significant predictor of increases in infant food responsiveness from 6 months to 14 months ($\beta = 0.24$, $p = 0.01$, 95% CI = 0.05–0.30) and was marginally associated with higher infant food responsiveness from 2 to 6 months ($\beta = 0.14$, $p = 0.08$, 95% CI = −0.01–0.23). Additionally, we observed parent-driven cross-lagged associations between situational food to soothe and food responsiveness. Greater use of situational food to soothe at 2 months was marginally associated with higher food responsiveness at 6 months ($\beta = 0.14$, $p = 0.07$, 95% CI = −0.01–0.23), and greater use of situational food to soothe at 6 months was marginally associated with higher food responsiveness at 14 months ($\beta = 0.16$, p =0.06, 95% CI = −0.01–0.22).

In sum, we observed (1) prospective associations between pressuring feeding styles (pressuring to finish and pressuring with cereal) and infant food responsiveness that were exclusively parent-driven and (2) and some evidence that situational food to soothe infant distress (e.g., while in the grocery store, in the car) is associated with increases in food responsiveness across infancy.

Discussion

This is the first study to prospectively examine associations between controlling parental feeding and child food responsiveness among children aged 2 years or less. Findings from this prospective, observational study suggest that a pressuring feeding style and the use of food to soothe infant distress may be one avenue by which children become more food responsive across infancy. The current study expands the field's understanding of reciprocal relations between controlling feeding and infant food responsiveness during a sensitive period for establishing children's appetitive behaviors.

As hypothesized, we observed unidirectional cross-lagged associations from pressuring feeding styles to infant food responsiveness. Greater pressuring to finish and pressuring with cereal predicted later increases in food responsiveness, however the effect of pressuring to finish was only statistically significant from 2 to 6 months whereas the effect of pressuring with cereal was only statistically significant from 6 to 14 months. The observed patterns of associations are in accord with the introduction to complementary foods that typically takes place between 4 and 6 months, thus providing an explanation for the

TABLE 1 Sample characteristics and descriptive statistics for primary variables (at baseline unless otherwise noted), $N = 176$.

Characteristic	*N*	% or Mean (SD)	
Maternal age, years	174	29.10 (5.92)	
Income to needs ratio	167	3.10 (2.98)	
Pre-pregnancy BMI, kg/m^2	163	28.41 (7.50)	
Pre-pregnancy weight status			
Underweight	5	3.1%	
Normal weight	66	40.5%	
Overweight	37	22.7%	
Obese	55	33.7%	
Maternal race/ethnicity			
Non-Hispanic White	81	46.0%	
Non-Hispanic Black	57	32.4%	
Hispanic/Other/Multiracial	38	21.6%	
Maternal education			
≤High school diploma/GED	37	21.5%	
Some college	40	23.3%	
2-year college degree	17	9.9%	
4-year college degree	35	20.3%	
Post graduate work/degree	43	25.0%	
Infant sex			
Male	84	50.3%	
Female	85	49.7%	
Infant gestational age, weeks	169	39.24 (1.44)	
Infant weight-for-age z-score at birth	169	−0.03 (1.15)	
Exclusive breastmilk, 2 months	151	68 (45.0%)	
Exclusive breastmilk, 6 months	145	50 (34.5%)	
	2 months (T1)	**6 months (T2)**	**14 months (T3)**
Infant age, months	2.24 (0.56)	7.12 (1.39)	15.02 (1.00)
Any breastfeeding	111 (73.5%)	81 (55.9%)	41 (31.8%)
Maternal controlling feeding			
Pressuring: finish	2.12 (0.77)	2.28 (0.67)	2.32 (0.74)
Pressuring: cereal	1.77 (0.84)	1.98 (0.99)	1.83 (0.92)
Restrictive: amount	2.91 (1.00)	2.87 (1.04)	2.77 (1.10)
Restrictive: diet quality	3.39 (0.84)	3.84 (0.65)	3.62 (0.84)
Food to soothe: situational	2.54 (0.92)	2.54 (0.97)	2.49 (0.92)
Food to soothe: state-based	2.67 (1.12)	2.77 (1.14)	2.56 (1.10)
Infant food responsiveness	2.72 (0.78)	2.34 (0.72)	2.73 (0.67)

emergence of pressuring with cereal as a more salient predictor of food responsiveness from 6 to 14 months in our sample. This is further evidenced by the observed increase in the pressuring with cereal mean score between 2 months ($M = 1.77$, $SD = 0.84$) and 6 months ($M = 1.98$, $SD = 0.99$). Our results build on previous mixed findings from longitudinal studies and converge with a prior study showing a prospective positive association between parental encouragement to eat and child tendency to overeat among children aged 1.5 to 2.5 years (29).

Our findings diverge from the bidirectional temporal relationship between higher pressure to eat and lower food responsiveness reported by Costa and colleagues, which was conducted across two time points when children were aged 4 to 7 years (28). Pressuring to eat among infants and toddlers may contribute to children's food-approach tendencies and push children to focus on external food cues rather than internal satiety signals (29). However, as children's food preferences strengthen and picky eating increases for many children during the toddler and preschool years, lower food responsiveness may prompt increases in encouragement to eat, which may end up being counterproductive, contributing to reduced food intake and lower interest in food (42, 43). Furthermore, the current study provides a more nuanced understanding of how different types of pressure may influence food responsiveness during infancy.

Also consistent with our hypotheses, we observed unidirectional cross-lagged associations between food to soothe and infant food responsiveness. Specifically, greater use of situational food to soothe was marginally associated with increases in food responsiveness from 2 to 6 months and 6 to 14 months. These findings build on previous research showing cross-sectional associations between the use of food to soothe and infant food responsiveness in infancy (37, 44) and one prospective study among preschool-age children showing a parent-driven effect (30). Our results are suggestive of a parent-driven effect of food to soothe on food responsiveness during infancy, particularly when food to soothe is used in situations (e.g., attending to another person, in the doctor's waiting room) in which parents may perceive that they do not have the ability or time to engage in alternative soothing strategies such as shushing or rocking their baby.

In line with prior cross-sectional research with children preschool-aged and older, we observed some evidence for concurrent correlations between a restrictive feeding style and food responsiveness (45, 46). At 6 months, higher food responsiveness was associated with greater restrictive feeding regarding food amount. This positive association between restricting food intake and food responsiveness was also apparent at 2 months and we observed an inverse correlation between restrictive feeding regarding diet quality at 12 months, though neither of these correlations reached statistical significance. Two prior studies have shown inverse longitudinal associations between restriction and food-approaching behaviors. Jansen and colleagues found that lower covert restriction (e.g., restriction the child is unaware of) predicted increases in food responsiveness from 2 to 3.7 years (47). Another study showed that restriction of food amount at 21 months predicted lower eating in the absence of hunger, an objective measure of a child's propensity to eat in response to external food cues, at 27 months (48). Our models, however, did not reveal any significant cross-lagged paths between restriction and food responsiveness, which could be explained by the lack of follow-up past 14 months in the current study. It is possible that restriction may only influence *changes* in children's food-approaching behaviors after the 1st year of life once exposure to a wider variety of foods, including less healthy energy-dense foods, becomes more common. Although evidence points to the possibility that restriction across infancy and toddlerhood may function as a protective factor, the role of restriction on the development of food-approaching behaviors remains unclear and additional research, particularly studies that measure different types of restriction (e.g., amount versus diet quality, covert vs. overt) across the first few years of life, is certainly needed.

The relative absence of a child-driven cross-lagged effect of food responsiveness on restrictive feeding in the current study did not support our hypothesis. Although a recent systematic review reported a pooled effect for a prospective positive association between food responsiveness and restriction (26), the findings from individual studies are mixed and primarily point to null longitudinal effects. Costa and colleagues found that parental perception of excess food intake (1-item adapted from the CEBQ food responsiveness scale) at age 4 predicted greater restriction 3 years later (28) whereas two other studies did not find evidence that food responsiveness influences restriction across 2-year (age 6 to 8 years) and four-year periods (age 2–4 to 5–7 years) (19, 30). In addition, child eating in the absence of hunger did not predict restriction in terms of amount or diet quality in a study conducted with toddlers (48). Taken together, there is little evidence to suggest that children's food responsiveness strongly influences maternal beliefs and behaviors surrounding how much and what types of food young children eat, and it is likely that it is children's weight, rather than their eating behaviors, that causes parental concern and subsequent restrictive feeding.

The effects observed in the current study were fairly small, which is consistent with previous research in this area (19, 26). Small effects were expected given the prospective cross-lagged models controlled for previous levels of controlling feeding and food responsiveness, which were both relatively stable (19), in addition to key covariates previously shown to influence these constructs (i.e., maternal age, race/ethnicity, pre-pregnancy BMI, socioeconomic status, infant birth weight, and breastfeeding status). Regardless, it is important to recognize the potential public health impact of controlling feeding on appetitive behaviors across infancy and early childhood. The relative stability of controlling feeding demonstrated in our study is consistent with research in older children (28, 30, 47, 48) and suggests that maternal feeding styles and practices are established by 1 year of age. This highlights the need for future research to examine factors that contribute to controlling feeding among infants, especially in the case of pressure given our results support a unidirectional parent-driven effect. The longitudinal stability of infant food responsiveness in the current study was lower than previously reported in studies conducted with children 2 years and older (27, 30, 47). Taken together, interventions that target maternal feeding after the 1st year may have limited success in modifying appetitive behaviors to reduce later obesity risk (47). Further, untested moderators may explain why several associations did not reach statistical significance and the small effects more generally. Future studies can extend this work by examining whether the tested associations depend on other child characteristics (e.g., temperament), maternal behaviors (e.g., feeding mode) or broader home environment

TABLE 2 Standardized path coefficients for model shown in Figure 1 ($N = 176$).

Path	Stability coefficients for infant FR		Stability coefficients for maternal feeding		Concurrent associations of infant FR and maternal feeding			Cross–lagged associations Maternal feeding predicting future infant FR		Cross–lagged associations Infant FR predicting future maternal feeding	
Maternal feeding variable	FR T1 → FR T2	FR T2 → FR T3	Maternal feeding T1 → Maternal feeding T2	Maternal feeding T2 → Maternal feeding T3	FR T1 → Maternal feeding T1	FR T2 → Maternal feeding T2	FR T3 → Maternal feeding T3	Maternal feeding T1 → FR T2	Maternal feeding T2 → FR T3	FR T1 → Maternal feeding T2	FR T2 → Maternal feeding T3
Path label in Figure 1	β1 (95% CI)	β2 (95% CI)	β3 (95% CI)	β4 (95% CI)	β5 (95% CI)	β6 (95% CI)	β7 (95% CI)	β8 (95% CI)	β9 (95% CI)	β10 (95% CI)	β11 (95% CI)
Pressuring–finish	0.30***	0.27**	0.53***	0.65***	0.21*	0.08	0.16+	0.23**	0.16+	0.08	0.04
	(0.13–0.42)	(0.09–0.40)	(0.37–0.61)	(0.56–0.86)	(0.03–0.21)	(−0.03–0.08)	(−0.01–0.11)	(0.07–0.38)	(−0.01–0.33)	(−1.07–1.20)	(−0.10–0.17)
Pressuring–cereal	0.32***	0.28**	0.44***	0.52***	0.14	0.17*	0.10	0.14+	0.24**	0.00	−0.02
	(0.15–0.44)	(0.11–0.42)	(0.30–0.55)	(0.40–0.69)	(−0.02–0.22)	(0.00–0.16)	(−0.04–0.12)	(−0.01–0.23)	(0.05–0.30)	(−0.15–0.15)	(−0.20–0.16)
Restrictive–amount	0.32***	0.26**	0.60***	0.67***	0.14+	0.19*	0.06	0.12	0.09	−0.02	−0.02
	(0.15–0.44)	(0.08–0.39)	(0.47–0.73)	(0.63–0.90)	(−0.01–0.23)	(0.01–0.17)	(−0.05–0.11)	(−0.03–0.20)	(−0.05–0.18)	(−0.18–0.13)	(−0.22–0.16)
Restrictive–diet quality	0.34***	0.28***	0.54***	0.60***	0.01	−0.00	−0.16+	0.02	−0.11	0.03	0.02
	(0.17–0.46)	(0.10–0.40)	(0.32–0.54)	(0.57–0.91)	(−0.10–0.11)	(−0.06–0.06)	(−0.13–0.01)	(−0.12–0.15)	(−0.27–0.05)	(−0.09–0.14)	(−0.14–0.17)
Food to soothe–situational	0.32***	0.25**	0.47***	0.64***	0.16+	0.04	0.03	0.14+	0.16+	0.09	0.08
	(0.15–0.44)	(0.07–0.38)	(0.36–0.64)	(0.49–0.74)	(−0.00–0.23)	(−0.07–0.10)	(−0.06–0.09)	(−0.01–0.23)	(−0.01–0.22)	(−0.06–0.28)	(−0.07–0.28)
Food to soothe–state–based	0.36***	0.28***	0.53***	0.64***	0.17*	0.06	−0.11	−0.09	0.05	0.01	0.11
	(0.18–0.47)	(0.11–0.41)	(0.41–0.69)	(0.50–0.74)	(0.00–0.29)	(−0.07–0.14)	(0.14–0.04)	(−0.16–0.05)	(−0.07–0.13)	(−0.20–0.21)	(−0.03–0.36)

$^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. FR = infant food responsiveness, T1 = infant age 2 months, T2 = infant age 6 months, T3 = infant age 14 months. Adjusted for time invariant covariates at T1: maternal age, race/ethnicity, socioeconomic status, pre-pregnancy BMI, and infant weight-for-age z-score at birth. Adjusted for time variant covariates at their respective time points: exact infant age at visit and breastfeeding status. Time invariant variables that were significantly associated with the outcomes at later time points were also entered as covariates: pressuring-finish (pre-pregnancy BMI on pressure-finish at T2); pressuring-cereal (maternal age on pressure-cereal at T2 and maternal education on pressure-cereal at T3); restrictive-amount (maternal race/ethnicity on restriction-amount at T2, maternal age on food responsiveness at T3, and income-to-needs ratio on restriction-amount at T3); restrictive-diet quality (maternal race/ethnicity on restrictive-diet quality at T2, infant weight-for-age z score at birth on restrictive-diet quality at T3, and maternal age on infant food responsiveness at T3); food to soothe-situational (maternal education on food to soothe at T2 and maternal age on food responsiveness at T3); food to soothe-state-based (maternal age on food to soothe at T2 and food responsiveness at T3, and maternal education on food to soothe at T3).

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factors (e.g., poverty status). Harris and colleagues, for example, found that the association between food responsiveness and the use of food to soothe depended on levels of negative affect and regulation (37), two dimensions of infant temperament that have been independently linked to food to soothe (15, 49).

Although the current study has several strengths, including a prospective design and adjustment for multiple covariates, our results must be considered in light of certain limitations. Although our sample was relatively diverse in terms of race/ethnicity and socioeconomic status, results may not generalize beyond a mid-sized Southeastern US city. Additionally, the sample size was somewhat small which may have reduced our ability to detect statistically significant effects. Given the small sample, we conducted separate path analysis models for each controlling feeding subscale. Further, satiety responsiveness (i.e., sensitivity to internal satiety cues) is another appetitive behavior that has been associated with infant weight in previous studies (2, 4). While we considered examining satiety responsiveness in the current study, this BEBQ subscale had low internal consistency reliability in our sample at the first two time points (αs = 0.39 and 0.47 at 2 months and 6 months respectively). Thus, we focused on food responsiveness only. Given the number of models tested in the current study, focusing on one appetitive behavior reduced the potential for Type 1 error. Studies with larger sample sizes that have the ability to test associations between food responsiveness (and other potentially important appetitive behaviors) and multiple feeding styles in one model are needed. Finally, measurement of both parental feeding and infant food responsiveness relied on parent reports, which are subject to social desirability and shared variance bias. However, the subscales reported were derived from widely used validated questionnaires and the food responsiveness subscale from the BEBQ has been validated against objective measures of appetitive behaviors (50). The potential for inflated associations due to the use of a single reporter might be reduced by the fact that the cross-lagged effects controlled for prior levels of both constructs, thus adjusting for bias in the cross-sectional paths (19). However, future longitudinal research that employs observational methods to assess parental controlling feeding is warranted.

Results from the current study reveal that pressuring, but not restrictive feeding styles, contribute to small increases in infant food responsiveness. There were no child-driven effects and our findings suggest that food responsiveness during infancy does not elicit parent's restrictive feeding. To build on trials that have had success in reducing controlling feeding, including pressuring feeding and food to soothe (51–53), qualitative studies are needed to better understand infant characteristics and contextual factors that contribute to feeding styles in order to provide more tailored messaging and support for parents in future interventions. Future work should also consider initiating feeding interventions during the prenatal period. Additional longitudinal studies that target infancy through early childhood are needed to understand how these associations unfold over time and whether child-driven effects of food responsiveness become apparent as children get older.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by University of North Carolina at Greensboro Institutional Review Board. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

EL, CB, LS, and LW contributed to the design and measurement approaches used in the iGrow study. SE conducted the primary analyses with some assistance from EL. SE drafted the manuscript. SE and EL had primary responsibility for the final content. All authors read and approved the final manuscript, contributed to the conceptualization of this manuscript, and revised the paper.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Ajyal Salima a novel public–private partnership model for childhood obesity prevention in the Arab countries

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The prevalence of childhood overweight and obesity among children is on the rise around the world. Meanwhile, comprehensive multi-sectorial approaches have been found to be effective in improving nutritional status among children. Ajyal Salima is a public–private partnership (PPP) school-based nutrition and physical activity intervention program implemented in six Arab countries. Its objective is to promote healthy eating and physical activity habits among 9–11-year-old students. The stakeholders, involved with the implementation of the program, comprised (1) local authorities, ministries of Education and Health, and non-governmental organizations (NGOs) as public partners, (2) The American University of Beirut (AUB) as the academic/regional scientific partner, and (3) Nestlé as the private partner. The Ajyal Salima program encompasses four coordinated educational components: classroom sessions, family involvement, food service intervention, and training of trainers. The program's educational material has been culturally adapted to each country's needs, as well as pilot tested. This paper describes the strategies used to build the PPP framework of Ajyal Salima, and the role of each stakeholder. The Ajyal Salima program is an example of a promising and sustainable comprehensive PPP program to address childhood obesity, that can be exported to other countries in the region and globally.

KEYWORDS
childhood, nutrition, obesity, school-based intervention, health promotion, Arab region, partnership

Introduction

The world is facing a progressive rise in the global prevalence of obesity, particularly childhood obesity that has increased from 31 to 42 million as reported by the World Health organization (WHO) (1). In the Arab region, a triple burden of malnutrition exists including undernutrition, micronutrient deficiency, and over nutrition. This region has elevated rates of obesity and non-communicable diseases (NCDs) that are associated with the rapid economic, social, and political changes in related countries.

Socio-economical changes have possibly led to a nutrition transition and transformation in the lifestyle of people in the region (2). Urbanization, technological development, and modernization have reportedly led to shifts in dietary habits, physical activity, and increased NCDs, particularly among children in the region (2). A striking increase in the rates of overweight and obesity have been noted in children in the Arab region where 25–40% of children and adolescents were reported to be overweight or obese (1, 3). Holistic interventions were reported as needed to modify the obesogenic food environment and facilitate adequate food choices for this vulnerable population (4). Targeting childhood overweight and obesity has become essential to help resolve public health problems, requiring urgent evidence-based approaches to reverse the trend (1). Programs designed to address the obesogenic environment need to be tailored to take into consideration cultural peculiarities and relevant food environments to achieve progress in mitigating childhood obesity.

According to the United Nations, a multisectoral approach that integrates various stakeholders, such as governments, local policy makers, health sectors, and civil society, is recommended to address malnutrition in children (5). This approach, known as the public–private partnerships (PPP), is defined as mobilization of funds from the private sector to governmental or non-governmental organizations (NGOs) to enhance their generally declining spending on public health issues (6). To be deemed successful, PPPs targeting childhood obesity need to be culture specific, encourage local engagement and long-term commitment, and include multiple stakeholders. Additionally, PPPs need to be evidence-based, undergo continuous monitoring and evaluation, and ensure that all stakeholders have access to program information and reports (7). Many reports from other countries have proven the PPP to be an effective tool in tackling the double burden of childhood obesity, specifically when a partnership is school based (8). Internationally, several PPP protocols for preventing childhood obesity that address dietary and sedentary behaviors were implemented in the United States (9–12), the United Kingdom (13), and Europe (14, 15). As for the Arab region, intervention programs targeting childhood overweight and obesity mostly focus on dietary modifications, while overlooking the interplay between behavioral, environmental, and psychological factors (16).

Ajyal Salima, which translates in English to "Healthier Kids," constitutes the region's sole PPP-based, multi-component, and holistic school-based nutrition intervention program to address the obesogenic environment. This paper describes the strategies and methodologies used to build the program's PPP framework, and the role of each stakeholder. It also serves as a model for the future development of similarly effective private–public partnerships to tackle rising obesity rates among schoolchildren elsewhere.

TABLE 1 Timetable for the Healthier Kids-Ajyal Salima rollout in the selected Arab countries with the relevant stakeholders involved.

Year	Program roll-out
2010	Launch of the program in Lebanon
	Partners:
	American University of Beirut
	Ministry of Education and Higher Education
	Nestlé Middle East FZE
2012	Pilot study of the program in UAE
	Partners:
	American University of Beirut
	Dubai Health Authority
	Princess Haya initiative
	Dubai Education Zone
	Nestlé Middle East FZE
2014	Pilot study of the program in KSA
	Partners:
	American University of Beirut
	Ministry of Education
	Tatweer Educational Holding Company
	Nestlé Middle East FZE
2014	Adoption of the program by the Lebanese Ministry of Education and Higher Education into their health education unit
2015	Launch of the program in Jordan
	Partners:
	American University of Beirut
	Ministry of Education
	Ministry of Health
	Non-Governmental organization: Royal Health Awareness Society (RHAS)
	Nestlé Middle East FZE
2016	Launch of the program in Palestine
	Partners:
	American University of Beirut
	Ministry of Education
	Nestlé Middle East FZE
2018	Launch of the program in Bahrain
	Partners:
	American University of Beirut
	Ministry of Health
	Ministry of Education
	Nestlé Middle East FZE

Methodology

Establishing partnerships and process of implementation

The Healthier Kids-Ajyal Salima school program was initially developed in 2008 by the American University of Beirut (AUB) as "Health-E-PALS" to tackle childhood obesity in Lebanon through addressing nutritional and physical activity habits of schoolchildren (17). The first Ajyal Salima PPP was established in Lebanon in 2010 between Nestlé Middle East FZE and AUB to expand the program's national coverage. The Lebanese Ministry of Education and Higher Education then joined as the public partner, helping Ajyal Salima further develop into a national program with its formal adoption by the Ministry in public schools. The research team at AUB was responsible for teacher training, monitoring and evaluation of the program implementation in both public and private schools.

Following the pilot year, and with the scientific support of AUB, Nestlé set out to expand the program's implantation in the region, engaging with different stakeholders and authorities, disseminating learnings from the program, putting together proposals for PPP collaborations, as well as providing the evidence of its effectiveness in promoting nutrition knowledge and enhancing healthy eating in school children (18). The PPP model and evidence-based results from the pilot study constituted the foundation to help establish collaboration and partnerships between local authorities and Nestlé in the United Arab Emirates (UAE), Kingdom of Saudi Arabia (KSA), Jordan, Palestine, and Bahrain. Individual agreements and frameworks on action plans tailored the program's governance and elements to each's specific needs, providing the set-up for local implementation, roles and responsibilities, monitoring, and evaluation. To roll out the program in these Arab countries, and in light of specific cultural peculiarities and local needs of the countries involved, the original program components were modified to suit local traditions, different types of food consumed, and their local names.

In the UAE, Palestine, and Bahrain, agreements were signed between governmental partners (Ministry of Health, Ministry of Education, and the Dubai Health Authority) and the private partner Nestlé Middle East FZE. The program was integrated into Palestinian strategic education and school health action plans. In Jordan and Saudi Arabia, the agreements were signed between Nestlé Middle East FZE and NGOs and agencies, the Royal Health Awareness Society (RHAS) in Jordan and Tatweer Education Holding in Saudi Arabia. The ministries in both Jordan and Saudi Arabia were also included in this collaboration framework. Table 1 presents the timeline for the Ajyal Salima rollout in various locations as well as respective partners and relevant stakeholders in each.

The role of each stakeholder is outlined in Figure 1, which describes the Ajyal Salima PPP. This partnership consisted of (1) Local authorities, mainly the Ministries of Education and Health, in addition to NGOs, which served as the country's public partners, endorsers, and gatekeepers. These authorities ensured that the program was embedded in relevant infrastructure, contributed to the local health strategy objectives, included in school health roadmaps, and ensured sustainability. Moreover, the engaged ministries secured access to schools and established on-site supervisors who followed up on the implementation of the Ajyal Salima program within them. (2) The AUB as the academic/regional scientific partner and coordinator provided the material for scientific dissemination, curriculum content development and adaptation, training of trainers, data analysis, and scientific publications. (3) Nestlé Middle East FZE, as the private partner, contributed to the development of the PPP model as part of the Nestlé for Healthier Kids Global Initiative and in line with its Creating Shared Value strategic approach. It led communication across the region, established partnerships, and supported logistics for replication, and expansion of the program; however, Nestlé did not play a role in the program's content, implementation and delivery nor in schools/students selection, segregation of data, or data analysis and reporting.

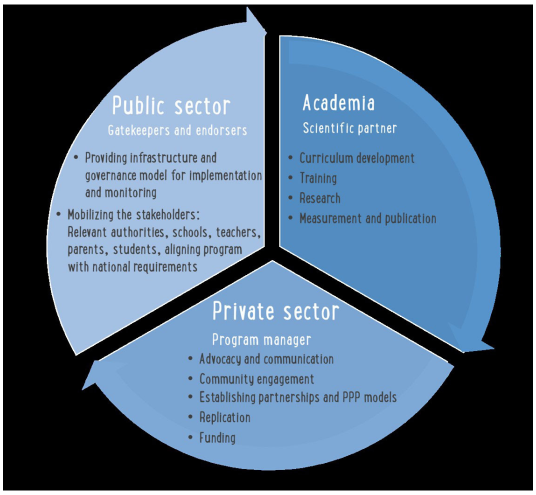

FIGURE 1
The Ajyal Salima private–public partnerships (PPP) model.

Process of development of Ajyal Salima intervention program

The Ajyal Salima program is a multi-component school-based intervention that relies on the Social Cognitive Theory, which goes beyond the acquisition of knowledge to include environmental modifications that support individual behavioral changes (19). The program has four coordinated intervention components that address an individual's behavior change including knowledge, skills, self-efficacy, environmental factors such as reinforcement of good behavior, modeling of significant others, as well as availability of recommended foods at home and in the school environment. These components were structured to work together to address behavioral and environmental factors related to students' dietary and physical activity behaviors in the school and at home. Consistent with the Social Cognitive

TABLE 2 Intervention components and target population.

Program's components	Number of sessions/meetings per year	Target population
Classroom sessions	**12 modules over the year:** 15–20 min lesson 20–25 min activity	Students (9–11-year-old)
Family program	**2–3 interventions included:** Parents meeting to introduce the programme Parents participation in an in-class activity Invitation for parents over breakfast End-of-year school event	Parents
School canteens	**Intervention included:** Providing healthy food choices Offering less energy dense snacks and drinks options	Food service personnel
Train the trainers	**2-day workshop:** Training provided by AUB research team Material included: Lesson plans, activity sheets, support material for parental meetings, and schools shops	Teachers and health educators

Theory, the components were based on the expectation that children will make healthier choices when introduced in a social setting that includes family and peers as well as using active learning strategies.

Intervention components

The Ajyal Salima intervention targets encouraging consumption of nutrient rich foods and specific energy balance-related behaviors such as physical activity, sedentary behaviors, and dietary intake that play a significant role in energy balance leading to weight gain in 9–11-year-old children (20, 21). Specifically, the intervention focused on addressing: (1) Increasing consumption of fruits and vegetables (2), Favoring healthy snacks over high energy dense snacks and drinks (3), Consuming a healthy breakfast daily (4), Increasing moderate physical activity (5), Decreasing sedentary behavior.

The four intervention components included:

1. Interactive classroom sessions: Culturally appropriate educational lessons, included fun and attractive material, designed to promote healthy eating, and physical activity, delivered by trained teachers. This component covered the personal and psychosocial determinants as outlined by the Social Cognitive Theory (19).
2. Parental involvement: The intervention program was introduced to families to assist them in creating a supportive environment at home for healthy lifestyle behaviors. Take-home packets including nutrition and physical activity tips, as well as recipes were sent with the students. Additionally, parents were invited to health fairs organized at the school. This component covered the obesogenic environment at home.
3. Food service intervention: This component covered the availability of food in the school environment and provided relevant recommendations to include a healthy list of snacks and drinks and exclude unhealthy choices for children in the school shop.
4. Train the trainers (TTT) workshops: workshops were conducted in each country and consisted of a 2-day interactive face-to-face training of teachers, by a research team of dietitians, on all program components and hands-on coaching and role-plays on all educational activities. Teachers and health educators in each country were coached on the use of a complete tool kit, which consisted of a "Teacher's guide" with lesson plans and educational material (posters, pamphlets, booklets...) to ensure the delivery of the intervention exactly as designed. In addition, school-specific implementation plans were discussed and agreed upon with teachers and school administration along with hands-on exercises, illustrative of the program. Table 2 presents the intervention components, the number of sessions or meetings per year for each component and the target population.

Program monitoring and evaluation

The outlined PPP model was designed to be implemented across all six countries, with results used to further expand it to other countries. Collectively, the Ajyal Salima PPP brought together ten partners across six countries and reached 300,000 schoolchildren, their parents, and teachers. Given that this was a large-scale PPP, it was vital to monitor the program and evaluate its efficacy to expand it into other countries. The evaluation process included a pre-test 1 week prior to the start of the intervention and a post-test 1 week after the completion of the program (3–4 months duration) in all schools. These tools were developed by AUB as the scientific partner, which is the custodian of the data that will be later analyzed and shared with all partners. Evaluation and monitoring involved all partners and stakeholders to ensure program sustainability and success. Ethical approval of the study was granted by AUB's Institutional Review Board in Lebanon. Additional approvals were obtained by the Ministries of Health and Education in Jordan, the Palestine, Bahrain, and Saudi Arabia.

Discussion and conclusion

This paper describes the Ajyal Salima regional program as a process and a model for implementing a PPP addressing childhood obesity and promoting healthy eating and physical activity in schoolchildren in different administrative settings. The Ajyal Salima program, which relied on the Social Cognitive Theory, is one of the first multi-component school-based interventions to be implemented in the Arab region that highlighted the importance of PPPs in addressing prevention of childhood obesity. It has been conceived as a gradual process involving development, piloting, adoption, rollout, and expansion through partnerships between different stakeholders from several Arab countries.

Public–private partnerships, now commonly used in the health sector, have been shown to be effective in promoting sustainable health programs, by enriching the capacity, quality, and reach of public health services and allowing innovation in the dissemination of health-related messages (22).

In the Ajyal Salima model, an integral part of the PPP was the research team at AUB as the academic partner responsible for all scientific aspects of the program, such as developing educational material and project tools, training of trainers, and monitoring and evaluation. A similar PPP is the Ensemble Prévenons l'Obésité Des Enfants (EPODE); a community-based program launched in France in 1992 involving an academic partner, as well as a public partner and NGOs (23). Four universities and numerous specialists/academics from different European countries were included in the partnership. The central coordination team, composed of specialists, coordinated the program, developed all the tools, and conducted continuous monitoring and evaluation (15). According to the EPODE experience, the PPP was a major factor for the success of the community-based methodology (23). Another example is the Food Hero model, where the research partner was responsible for drafting all survey tools, recruiting participants, conducting focus groups, analyzing data, and publishing progress reports (12). Additionally, the United for Healthier Kids (U4HK) program mobilized social media and social marketing to tackle childhood obesity in 11 countries (7). The U4HK program extensively relied on academic partners to develop science-based behavioral goals and develop the overall framework (7). In all PPPs scientific partners mobilize resources and share experiences to ensure the program's success. They are also responsible for the dissemination of results through research publication. The scientific evaluation is an integral part of a PPP as it ensures program's sustainability and encourages political involvement (23).

In all six countries that were included in the Ajyal Salima PPP model, there was a local public partner endorsing the program, mainly the local ministry of education or the ministry of health, or both simultaneously. Involving a public partner is important to ensure that the program is culture sensitive and abides by local rules, regulations, and local policies. Public partners have the authority and ability to mobilize large scale networks to secure implementation and sustainability of the program. For example, in the present PPP model, public partners secured schools' participation in the program and, in Lebanon and Palestine, embedded the model into their school curriculum. Similarly, the InFANT Program in Australia was adopted and endorsed by eight local governmental areas (24). Likewise, the U4HK program had different public partners in each participating country. One example is Mexico, where the public partners were the Ministries of Public Education and Health. In the Philippines, the Food and Nutrition Research Institute, the Department of Tourism, and the Central Bank were public partners (7). In other cases, public partners funded the intervention such as with the Pro Children program where governmental organizations were responsible for the recruitment of schools and funded the program across nine European countries (14). Public partners have a central role in any PPP addressing childhood obesity because they are the ultimate custodian of health in the country and they set policies, manage public schools, and have the leverage to make childhood obesity prevention a priority (23).

Another indispensable component of a PPP is the private sector, from which partners engage with stakeholders, create partnerships and program set-up for replication, mobilize resources, funds, and expertise to serve the program. The private partner in the Ajyal Salima model, Nestlé Middle East FZE, initiated and funded the program, and connected all involved partners from the region to achieve a common goal. Program communication was the responsibility of the private partner, which was also the case in the Change4Life PPP in which marketing agencies were recruited to create a social movement (13). Similarly, in the Food Hero PPP, the private marketing partner managed the program and employed its expertise to assist in creating it (12). Alternatively, other programs were solely dependent on the private partner, such as the Fuel up to Play program where two private partners, in collaboration with experts and school stakeholders, were responsible for program coordination and social marketing (10). Research has shown that there is a crucial need to involve the private sector in interventions targeting childhood obesity since this sector creates changes in the food supply and food environment and can lead to a positive evolution in product reformulation and advertising aimed at children (7). Many PPPs aiming to combat hunger and increase food security have been funded by large food companies because of their wide reach as they operate globally and can implement large scale programs (25).

Many PPPs started up as small-scale programs, such as the Food Hero and the Fuel Up to Play, later expanding to reach a wider audience (10, 12). The EPODE program was piloted in 10 French communities, and now operates in over 500 communities across the globe (15). Likewise, Ajyal Salima began as a pilot study in Lebanon in 2010 and now, over a decade later, continues to run in four countries. The key to a successful PPP is including both public and private sector partners along with NGOs and scientific experts from civil society. Open communication channels and well-structured protocols are also needed to ensure that all partners are working together through shared objectives, and by compelling/pooling resources and sharing the risks as well as benefits. Either public or private partners can lead or fund the program depending on resource availabilities and expertise. Ideally funding should be provided from the public sector, however, this is not always the case especially in low and low to middle income countries due to lack of governmental funds. Additionally, funding from private grants is usually for a longer duration which ensures better program sustainability (15). Likewise, interventions without the involvement of the public sector are not sustainable. The public partner ensures a program's sustainability through providing the necessary logistics and recruitment support. Some challenges or miscommunications might arise between the private and public partner, hence the importance of transparency, formal commitment, patience, and mutual trust. For example, in the Ajyal Salima PPP, detailed memorandums of understanding were signed across partners that included regulations, responsibilities, and rights. Partners also shared continuous progress reports and made sure that all information was available and accessible. Lastly, communication issues might arise when the program is running in various sites/countries with a different private partner in each. This was not the case in the context of Ajyal Salima program, as the private partner was the same across all sites.

There had been various school-based interventions in the region that targeted childhood overweight and obesity. For example, in Lebanon, the "Jarrib Baleha" intervention aimed to decrease intake of soft drinks and increase intake of water through interactive sessions (26). Three other school-based interventions were also implemented in Lebanon, though they targeted vulnerable populations such as Syrian and Palestinian refugees. These interventions aimed to increase nutritional knowledge among school children and provide complementary nutritious meals at school to improve school attendance rates (27–29). In Tunisia, a 3-year school-based intervention program was successful in increasing intake of fruits and vegetables and decreasing rates of overweight and obesity among children aged 11–16 (30). The Ajyal Salima PPP remains the first roadmap for addressing obesity challenges in Arab countries which allows for further emulation and program expansion into other countries across the region and possibly around the world. The model is holistic in its approach as it involved governments, schools, families, private, public, and industry sectors. The Ajyal Salima program includes multi-components, such as interactive classroom sessions, family orientation sessions, food service intervention, and training of trainer's workshops—Similar to other global interventions conducted to combat childhood obesity. All partners involved in the Ajyal Salima program were meeting their objectives. The public partners met national health strategies, specific for their country. The private partner, Nestlé Middle East FZE, was delivering on its Creating Shared Value commitments, in line with the global initiative. Similarly, the academic partner, AUB, was fulfilling its mission of providing research knowledge and introducing innovative programs to the scientific field through evidence-based research and community outreach. Additionally, the NGOs were achieving their goals of social development through inducing positive change within their communities. All partners were working systematically toward one common goal: implementing the Ajyal Salima program efficiently to ensure its highest impact and eventually decrease rates of childhood obesity. Despite its strength, this Ajyal Salima PPP model has some sustainability limitations; since the entire model relied on the engagement of three stakeholders, its effectiveness could be jeopardized in case one of the partners drops out. The active involvement and endorsement of government and local authorities' partners are critical to the program sustainability. Changes to the local educational authorities and health institutions roles and structure in the United Arab Emirates and in the Kingdom of Saudi Arabia prevented the program continuation and affected sustainability; the program continues to be implemented in four out of six countries: Lebanon, Jordan, Palestine, and Bahrain.

To ensure a wider implementation of the Ajyal Salima program, a deep evaluation of the efficacy and acceptability of the program components has been conducted across different countries and contexts, with results of the full-scale data analysis to be shared at a later stage.

In conclusion, this paper provided a detailed description for the implementation of a holistic school-based PPP intervention model addressing the food environment for the promotion and adoption of healthy eating and physical activity. Further expansion of the Ajyal Salima program may mitigate obesity and improve health of the Arab population; it could contribute to the existing body of literature espousing the possible success of multi-component intervention programs that include multiple partners and stakeholders from both the public and private sectors to prevent childhood obesity.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Author contributions

CH-M and NH conceived the original idea and developed it, provided detailed feedback on the full manuscript, and contributed to revisions. CH-M wrote the original draft. All authors contributed to the article and approved the submitted version.

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Conflict of interest

This study received funding from Nestlé. The funder had the following involvement with the study: Contributed to the development of the PPP model as one of the program stakeholders. They led coordination efforts across the region to establish partnerships and supported the logistics of the program. All authors declare no other competing interests.

Publisher's note

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Process and effect evaluation of the app-based parenting program *Samen Happie!* on infant zBMI: A randomized controlled trial

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Background: Although energy balance-related parenting practices are regarded critical components in the prevention of childhood obesity, most programs targeting parenting practices with respect to a wide range of energy balance-related behaviors were not aimed at high-risk families with a lower socioeconomic position (SEP).

Objective: The *Samen Happie!* app-based program aimed to stimulate healthy child weight development especially among families with a lower SEP, by encouraging healthy energy balance-related parenting practices.

Methods: A two-armed randomized controlled trial examined the process and effectiveness of the *Samen Happie!* program on child zBMI outcomes at 6- and 12-months follow-up. In total, 357 Dutch parents with infants aged 5–15 months old at baseline participated. Parents in the app condition (n = 179) received access to the *Samen Happie!* app and were compared to a waitlist-control condition (n = 178). Changes in zBMI were examined through linear mixed-effects models based on intention-to-treat and exploratory per-protocol principles.

Results: Process data showed low levels of sustained app use and moderate app acceptability. A general increase in child zBMI was observed in both conditions after 6 and 12 months. Intention-to-treat analyses using multiple imputations showed several statistically significant differences between conditions and high-risk subgroups. Specifically, at 6-months follow-up, zBMI increase was least pronounced in the app condition among children of parents with lower educational level. These findings were supported by exploratory per-protocol analyses including only frequent app users. In addition, per-protocol analyses showed benefits of app use at 6-months follow-up for children of parents with higher BMI. However, these effects were reversed at 12-months follow-up in both intention-to-treat and per-protocol analyses, where children of parents in the app condition in general increased the most in zBMI.

Conclusions: This study suggests that the *Samen Happie!* program might prevent zBMI increases after 6 months among children of parents with lower educational level, and children of parents with higher BMI who more frequently use the app. However, the app did not prevent increases in zBMI after 12 months. Future research should investigate strategies to increase sustained app use and engagement in mHealth parenting programs for childhood obesity as well as options to combine app-based programs with additional support strategies aimed at high-risk families.

Trial registration: Netherlands trial register (ID: NTR6938), https://trialsearch.who.int/Trial2.aspx?TrialID=NTR6938.

KEYWORDS

childhood obesity, preventive intervention, parenting practices, energy balance-related behavior, socioeconomic position (SEP), mHealth, behavior change

1. Introduction

Childhood overweight and obesity remain urgent medical and societal problems that disproportionally affect children coming from families with a lower socioeconomic position (SEP). On average, 8% of Dutch children around the age of 2 had overweight or obesity in 2018 (1), but the prevalence varies based on parental educational level [i.e., a common indicator of SEP showing consistent inverse associations with child adiposity; (2, 3)]. Compared to children of higher-educated parents, Dutch children of parents with middle and lower educational level have 1.96- and 2.76-times higher risks of developing overweight and obesity in childhood, respectively (4). This SEP-gradient in adiposity, as well as the various obesity-related physical and psychosocial health consequences (5), the difficulty to treat the condition (6), the link between rapid weight gain in infancy and childhood overweight (7, 8), and the likelihood of obesity tracking into childhood and adulthood (9, 10) all emphasize the need for early obesity prevention tailored at families of parents with lower educational levels. As such, it is imperative that healthy energy balance-related behaviors [EBRBs: i.e., dietary intake, sleep, and physical (in)activity] underlying weight changes are established as soon as possible, during the first years of life (11). In these early years, children's EBRBs and subsequent weight status are predominantly managed and supported by their parents. This makes the stimulation of healthy energy balance-related parenting practices [i.e., specific, discrete, and observable acts of parenting related to child EBRB; (12)] a key component in early preventive interventions for childhood obesity (13). The goal of the present study is to test an innovative app-based preventive program for early childhood obesity addressing healthy energy balance-related parenting practices.

Of note, previous prevention programs have already shown potential positive effects on healthy weight outcomes by promoting parenting practices with respect to child dietary intake [e.g., responsive feeding (14–16), structure and rule setting (14)], and sleep [e.g., bedtime routines; (17)]. Moreover, reviews on parenting practices related to child physical activity suggest the importance of parental role modeling (18, 19). However, most early childhood prevention programs (i.e., <5 years) targeting energy balance-related parenting have been limited in one of two ways. They either targeted some (but not all) EBRBs [i.e., most focused on dietary intake and/or physical activity; (16)] or they were universal (i.e., population-based) in nature, thereby not specifically directed at families that need it the most, including those with a lower SEP (16, 20, 21). As patterns of energy balance-related behaviors tend to cluster and unhealthier clusters are more frequently observed in families with a lower SEP [e.g., (22, 23)], targeting multiple EBRBs in families with lower SEP seems imperative. Our preventive parenting program aimed to overcome these limitations of previous studies by preventing childhood obesity through the stimulation of healthy parenting practices with respect to three important child EBRBs [i.e., child dietary intake, sleep, and physical (in)activity], while simultaneously applying selective prevention to a subgroup of parents with a lower SEP.

Our preventive parenting program was delivered *via* an app to facilitate the reach of deprived populations (24) and included relevant and engaging content and techniques through continuous co-creation with the target group. As such, our app-based program may specifically benefit families with a lower SEP that need the most help in terms of improving parenting practices and the home food environment (25–28). Moreover, two other risk groups that might also benefit more from the program are children of parents who have overweight and those of parents who experience mental health problems. To date, reviews have shown that children of parents with overweight or obesity have increased chances of developing overweight in childhood (29, 30). Although the exact mechanisms underlying this association are complex, it is presumed that a generally unhealthier home environment and more obesity-promoting parenting practices [e.g., parents with overweight apply less modeling of healthy food intake; (31)] can exacerbate the child's genetic predisposition for adiposity [e.g., (30, 32)]. Moreover, parental mental health problems can affect child development through various mechanisms [e.g., epigenetic processes during pregnancy (33), changes in breast milk (34)], including unhealthy parenting mechanisms in which mental problems impact parents' own EBRBs and reduce parents' responsiveness to their children's needs (35). Specifically, mothers who experience depressive symptoms more often apply unhealthy parenting practices such as parental modeling of unhealthy food intake, using food as a reward, and providing less structured sleep and activity-time (35–39). Notably, as our program targets particularly those parenting practices that are often less optimal among parents with obesity and depressive symptoms, children of these parents might also benefit more from the program. In addition, the app also targeted parents' own wellbeing by offering strategies to reduce stress and enjoy parenting (e.g., mindful parenting), and children of parents with depressive symptoms might experience benefits because of this as well. As the program aims to facilitate both child health and parental wellbeing and focuses for a large part on child dietary intake, we gave the program a Dutch title with a double meaning: *Samen Happie!*. Literal translations are "Happy Together" or "Eating Together," but neither of these titles reflect the play on words in the Dutch language. We will therefore use the Dutch title throughout the paper.

1.1. The present study

The present study examined the effectiveness of the *Samen Happie!* app-based program in terms of reach, use, acceptability, and child zBMI among Dutch parents and infants (aged 5–15 months at the start of the program). We hypothesized that children of parents who used the *Samen Happie!* app would have a lower zBMI at 6 and 12 months after the start of the program than children of parents who did not use the app. Furthermore, we expected that these effects on child zBMI after 6 and 12 months would be particularly strong for children of parents who had a lower educational level, higher BMI, and more depressive symptoms.

2. Materials and methods

This randomized controlled intervention study employed a between-participants design with two parallel conditions: an app-based intervention condition and a waitlist-control condition. This study is part of a larger preventive intervention program being evaluated in two separate trials (i.e., Trial 1 included parents of infants and Trial 2 included parents of toddlers), both of which have been published together as study protocol (40). The present study focused on the process and effectiveness of the program in Trial 1. Key elements of the protocol pertaining to this trial are described below. The methods, materials, and analyses for this study were pre-registered (https://osf.io/hfvda).

2.1. Study participants and procedures

Trial 1 of the *Samen Happie!* program was conducted in the Netherlands between January 2018 and November 2019. Parents were eligible for participation in this trial if their child was between 5 and 15 months old at baseline and did not suffer from chronic disease or disability that severely affected normal development (e.g., chromosomal disorders, diabetes, cystic fibrosis), as indicated by parents in a web-based screening. We asked the primary caregiver of a child to participate in the trial. We further strived to include a minimum of 300 parents, of whom at least 50% had a middle or lower educational level [see study protocol (40) for power calculations]. Participants were recruited both offline (e.g., through child day care centers and preventive child health clinics for young children) and online (e.g., through Facebook groups). A diversity of locations and websites were used to ensure recruitment took place among parents of all educational levels. Eligible parents who completed the screening were forwarded to a consent form and subsequent baseline questionnaire. Parents were enrolled in the trial when they completed the web-based screening, the consent form, and the baseline questionnaire. Parents in both conditions were told that the aim of the trial was to investigate ways to assist families in healthy parenting, and that half of the study participants would receive an app that could help with healthy parenting. Parents that were allocated to the waitlist-control condition knew that they would receive access to the app at the end of the trial. The procedures of the trial were approved by the Ethics Committee Social Sciences, Radboud University, the Netherlands (ECSS-2017-013).

Randomization of the enrolled parents took place in September 2018. A simple randomization procedure (i.e., a computer-generated list of random numbers) to randomly allocate participants to the app or control condition (allocation ratio 1:1) was performed by an independent researcher using SPSS version 24. Among research with larger sample sizes ($N > 200$), this procedure can be trusted to produce equal samples in terms of numbers and covariates (41, 42). Parents who were allocated to the app condition received a personal invitation code for the *Samen Happie!* app and instructions on how to download and use the app. There were no instructions regarding the timing and frequency of the use of the app to stay as close as possible to app usage patterns in everyday life. A visual representation of the trial flow and its timing is presented in Figure 1.

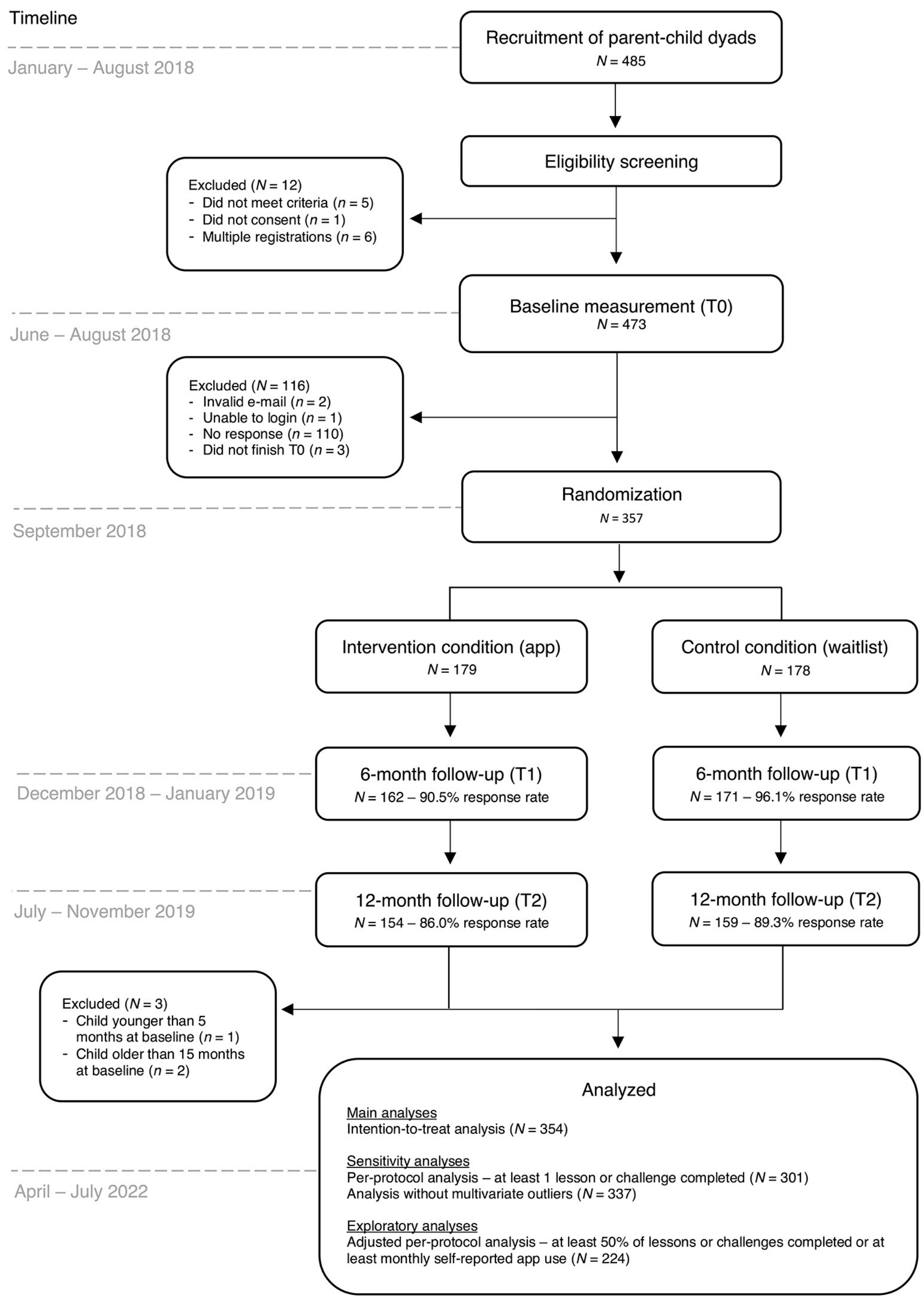

FIGURE 1
Flow chart of the *Samen Happie!* trial including information on its design, timing, and number of participants.

2.2. The *Samen Happie!* program

The *Samen Happie!* program was developed using the Intervention Mapping Protocol (43), which included the integration of theory and empirical evidence as well as data from and continued co-creation with the target population. The program specifically addressed the needs of parents with a lower SEP through tailored program content and theory-based behavior change techniques, which were selected from behavior change taxonomies by Kok et al. (44) and Michie et al. (45).

The program was delivered *via* a stand-alone, easy-to-use app consisting of five age-based modules: 7–12, 12–15, 15–18, 18–24, and 24–28 months. All parents in Trial 1 started in one of the first three modules at baseline. When the child reached the minimum age of the subsequent module, the new module became unlocked. Each age-based module provided parents with information (i.e., lessons) and exercises (i.e., challenges) about healthy parenting practices with respect to child EBRBs, as well as parental wellbeing and child temper (only lessons). Information in the lessons was presented in an engaging and easy-to-comprehend way, for instance through facts ("Did you know...?"), practical examples, tips, and quizzes, and was supported by icons and pictures. The challenges consisted of exercises that prompted parents to apply the information from the lessons in their day-to-day life. By employing techniques that tackle (unhealthy) automatic behaviors, parents were encouraged to implement (newly learned) parenting skills as habits. A more detailed description of the development, design, and content of the program can be found in the study protocol (40).

2.3. Data collection

Data were collected *via* web-based questionnaires at three timepoints: before the start of the program (T0), and after ~6 (T1) and 12 months (T2; see Figure 1 for the timing of the questionnaires). Non-responders were sent reminders *via* e-mail every 2 weeks during the measurement periods, with a maximum of 10 reminders at T2. Participants were compensated for their time and effort with a €10 gift card or a pack of diapers upon completing each questionnaire. Mean ages of the children at each questionnaire were 9.85 ($SD = 2.24$), 15.37 ($SD = 2.54$), and 22.87 ($SD = 2.47$) months at T0–T2, respectively.

2.3.1. Assessment of child and parent characteristics

2.3.1.1. Sociodemographic characteristics

Sociodemographic characteristics of the child that were collected at baseline (T0) included age, sex, and whether the child was first-born. Regarding breastfeeding, parents reported whether the child was ever breast-fed and the duration of breastfeeding (in months) at each measurement (T0-T2). For the parent, the following sociodemographic characteristics were collected at T0: age, relationship to child (i.e., biological father, biological mother, or other: foster, adoptive or other non-biological father/mother, partner of the biological father/mother, grandfather/grandmother, or guardian), educational level (i.e., primary school, preparatory vocational education, vocational education, pre-university, university), country of birth, parental relationship status, employment status, and financial difficulty (i.e., having difficulty paying bills over the past year). Parental educational level was dichotomized as lower (i.e., primary school, preparatory vocational education, vocational education) and higher educational level (i.e., pre-university and university).

2.3.1.2. Parental depressive symptoms

Parental depressive symptoms were assessed using the Edinburg Postnatal Depression Scale [EPDS; (46)], which is a brief and highly acceptable self-report scale that can be reliably be used in non-postnatal women with older children (47). We used the Dutch translation validated by Pop et al. (48). The questionnaire consists of 10 Likert-scale items (response categories: 0–3) in which parents report how they felt in the past 7 days (e.g., "I have felt sad or miserable"). A total score for depressive symptoms at T0 was calculated by summing the responses on all EPDS items (possible range: 0–30), with higher scores indicating more depressive symptoms. The scale showed good internal consistency (Cronbach's alpha = 0.83).

2.3.2. Assessment of app use

App use was assessed in two ways. First, through self-reports in the two follow-up questionnaires (T1 and T2), including questions about whether parents had downloaded the app (and if not, why), whether they still had the app installed on their phone (and if not, why), and how many times they had used the app. Second, objective characteristics of parents' app use were collected in an online database (e.g., the number and type of lessons and challenges started and/or completed).

2.3.3. Assessment of app acceptability

At T1 and T2, we asked parents about their experiences with the app, including several indicators of functionality (e.g., ease of use), design, and content (e.g., usefulness) on a scale from 1 (bad experience) to 7 (good experience). These questions were adapted from the Mobile App Rating Scale (49). Parents also rated the app as a whole and indicated whether they would recommend the app to family or friends on a scale from 1 to 10, with higher scores indicating higher appreciation and a higher likelihood of recommendation. Finally, we asked open-ended questions about the ways in which parents thought the app could be improved.

2.3.4. Assessment of parent and child anthropometry

Parents reported their height and weight at T0, from which we calculated parental BMI by dividing weight in kilograms by the squared height in meters. To assess child BMI, parents were asked to report the height and weight of the child as measured and reported by the youth health professional at their last visit to the preventive child health clinic (when available) at all three assessments. Parents were asked: "When was your child's height and weight measured at the preventive child health clinic for the last time?", "What was the weight of your child in grams on that day?", and "What was the length of your child in centimeters on that day?". These questions were administered at T0–T2. Additionally, at the second follow-up (T2), parents were asked to send a picture or screenshot of the (digital) measurement overview provided by the preventive child health clinic (containing height and weight measurements from the moment of birth up until T2).

Standardized BMI scores at T0–T2 were calculated based on child height (in cm) and weight (in kilograms) using the anthro_zscores function of the anthro package (50) in R (51). Standardization according to child sex and age was based on WHO Growth Standards (52). Child height and weight were derived from parent reports at T0–T2. When entries were missing, we consulted data from the (digital) measurement overviews (if available). Correlations between parent reports and data from the measurement overviews were high ($r = 0.95$ at T0, $r = 0.74$ at T1, $r = 0.89$ at T2 for height and $r = 0.96$ at T0, $r = 0.97$ at T1, $r = 0.79$ at T2 for weight). Because parents reported the height and weight data based on scheduled visits to the preventive child health clinic, zBMI measurements did not always line up with the timing of the questionnaires. To calculate zBMI, we only used height and weight data (both parent-reported and from the measurement overview) that were measured no more than 3 months prior to the moment parents completed the questionnaire. Mean ages of the children at the zBMI measurements were 8.98 ($SD = 2.47$), 14.18 ($SD = 2.30$), and 22.22 ($SD = 2.91$) months at T0–T2, respectively.

2.4. Statistical analysis

Our hypotheses were tested with linear mixed-effects models to account for the nesting of repeated measures within participants. Four mixed effects models were performed in R (51) using the lmer function of the lmerTest package (53), which calls the lmer function of the lme4 package (54). Each model included a random intercept varying over participants (i.e., modeling per-participant random adjustments to the fixed intercept). To test the shorter-term and longer-term effects of the intervention, two time contrasts were created using simple contrasts: a shorter-term predictor comparing baseline vs. follow-up 1 (T0 coded as −1/3, T1 as +2/3, and T2 as −1/3) and a longer-term predictor comparing baseline vs. follow-up 2 (T0 coded as −1/3, T1 as −1/3, and T2 as +2/3). Contrast coding was also used for the categorical predictors condition (control condition coded as −1/2 and app condition as +1/2) and parental educational level (lower educational level coded as −1/2 and higher as +1/2). The model testing the first hypothesis (i.e., the overall intervention effect) included a fixed intercept, a fixed slope for the factor condition, a fixed slope for the factor shorter-term follow-up, a fixed slope for the factor longer-term follow-up, and two fixed slopes for the interactions between both time contrasts and condition. The model testing the moderating effect of parental educational level included all predictors of the first model plus the three-way interactions between both time contrasts, condition, and parental educational level, as well as the main effect of parental educational level and its lower-order interactions. The model testing the moderating effect of parental BMI included all predictors of the first model plus the three-way interactions between both time contrasts, condition, and parental BMI, as well as the main effect of parental BMI and its lower-order interactions. Lastly, the model testing the moderating effect of parental depressive symptoms included all predictors of the first model plus the three-way interactions between both time contrasts, condition, and parental depressive symptoms, as well as the main effect of parental depressive symptoms and its lower-order interactions. The continuous predictors parental BMI and parental depressive symptoms were centered.

Following the CONSORT guidelines for reporting RCTs (55), the analyses were performed according to the intention-to-treat (ITT) principle (i.e., including all randomized participants adhering to the inclusion criteria). To assess the robustness of the findings, two types of sensitivity analyses were performed for all four models: (1) analyses excluding multivariate outliers identified using Mahalanobis distance [where observations > 3 *SD*s from the mean were considered outliers; (56)], and (2) per-protocol (PP) analyses including only participants in the app condition who completed at least one lesson or challenge (vs. the control condition). Statistical significance of parameter estimates was determined based on *p*-values provided by lmerTest. Coefficients were considered statistically significant if $p < 0.05$. Confidence intervals were determined using lme4's confint function using bootstrapping with 1,000 simulations. Statistically significant interaction effects were interpreted by extracting and comparing estimated means using the emmeans function from the emmeans package (57).

During the analysis process, we observed that the outcome variable child zBMI contained a considerable amount of missingness (see Study Participants in the Results section for details). We therefore imputed missing data *via* multivariate imputations by chained equations using the mice function of the mice package (58). Twenty imputations were performed within the app and control condition separately and the results of the individual imputations were pooled using mice's pool function. Both the results of the analyses in the non-imputed and in the imputed data are presented in the paper.

2.4.1. Deviations from pre-registration

We deviated from the pre-registration in two ways. First, *p*-values for the parameter estimates were derived *via* the lmerTest function instead of the mixed function from the afex package (59) for reasons of consistency across imputed and non-imputed analyses. This means that degrees of freedom were calculated *via* the Sattherwaite method, instead of the Kenward-Roger approach [which have shown to produce similar results; (60)]. Second, we unintentionally failed to specify the two-way interactions between each of the moderators and time and condition (e.g., parental educational level * time, parental educational level * condition) in the pre-registration, and included all possible lower-order interactions in the final analyses.

2.4.2. Exploratory analyses

Based on observed differences in participants' program use (see App Use for details) we performed exploratory, more stringent PP analyses to explore intervention effects among participants with higher program use (vs. the control condition) in addition to our pre-registered (less stringent) per-protocol analyses. The initially planned PP analyses included participants in the app condition who completed at least 1 lesson or challenge during the program period (vs. participants in the control condition). On hindsight, this criterium for program use might have been too loosely specified. For the app to have an effect, parents should have been exposed to a substantial amount of app content and/or have engaged with the content frequently. Therefore, additional, more stringent PP analyses were explored including participants who (1) completed at least 50% of the available lessons at T2 ($n = 19$), or (2) completed at least 50% of the available challenges at T2 ($n = 29$), or (3) reported to use the app at least monthly at T1 ($n = 27$). Due to overlap in participants between the three criteria, a total of 47 participants with higher app use were included in the adjusted PP analyses and compared to the control condition ($n = 177$). These exploratory PP analyses were performed in both the non-imputed and imputed data.

3. Results

3.1. Study participants

A total of 485 parents were recruited; however, 128 parents were not enrolled in the trial for different reasons, for example because they did not complete the baseline questionnaire (see Figure 1). The final randomized sample included 357 primary caregivers (179 in the app condition and 178 in the control condition; see Figure 1). No parents were excluded based on their child's health condition, as the conditions that parents specified (e.g., cow's milk allergy and/or reflux, skin conditions such as eczema) did not severely impact the child's (weight) development. Three parents were excluded from the analyses because their child was younger than 5 months or older than 15 months at baseline, resulting in a final analytic sample of 354 participants (177 in the app condition and 177 in the control condition).

Retention in the study was high, with response rates of 94.1% (333/354) at T1 and 88.4% (313/354) at T2. A considerable amount of missingness was observed in the outcome variable child zBMI at T1 and T2 (42.6% (142/333) at T1 and 64.9% (203/313) at T2), which probably resulted from our request to report child length and height based on measures reported at the preventive child health clinic. These measurements are scheduled at specific ages (e.g., at 5, 9, 11, and 14 months) and become less frequent over time (i.e., after 18 months there are only yearly visits at 2, 3, and 4 years), therefore potentially resulting in missingness at specific ages. Independent samples t-test showed that children with missing data on zBMI at T2 were on average 22.20 months old ($SD = 2.09$), whereas those who did not have missing data on zBMI were significantly older [$M = 23.55$, $SD = 2.63$, $t_{(303)} = 4.95$, $p < 0.001$] and closer in age to the standard visit to the preventive child health clinic at 2 years. Participants with and without missing values for child zBMI at T1 and T2 did not differ based on child sex, age of the parent, BMI of the parent, parental depressive symptoms, parental educational level, parental employment status, and parental financial difficulty (p's > 0.05).

3.2. Baseline characteristics

Descriptions of parent and child characteristics at baseline across the app and control conditions are provided in Table 1. Correlations between these variables at baseline are presented in Table 2. We found a positive but small association between child age and child zBMI ($r = 0.13$), indicating that being older was associated with higher zBMI scores. No other statistically significant associations between the outcome variable zBMI and parent or child characteristics at baseline were observed.

3.3. App use

3.3.1. Self-reported app use

After randomization, all 177 parents in the app condition received an invitation to download and use the app. At T1, 77.7% (122/157) of parents in the app condition reported they downloaded the *Samen Happie!* app. These numbers are comparable at T2 (75.3%, 113/150). The most frequently mentioned reasons for not downloading the app at T1 were that parents forgot to download it (51.4%, 18/35) or that they did not receive the e-mail with download instructions we sent them (31.4%, 11/35). At T1, 86.1% (105/122) of parents who downloaded the app reported that they still had the app installed on their phone, which decreased to 70.0% (70/113) at T2. Most parents who had the app installed on their phone at T1 and T2 reported that they used it several times after installing, but not anymore at T1 (70.5%, 74/105) or at T2

TABLE 1 Baseline parent and child characteristics by intervention condition.

Characteristic	App condition ($n = 177$)	Control condition ($n = 177$)
Parent		
Age in years, *M* (*SD*)	30.31 (4.13)	30.23 (3.93)
Relationship to child, *n* (%)		
Biological mother	171 (96.61)	171 (96.61)
Biological father	4 (2.26)	4 (2.26)
Other	2 (1.12)	2 (1.12)
In a romantic relationship, *n* (%)		
Yes, cohabiting with partner	167 (94.35)	165 (93.22)
Yes, not cohabiting with partner	3 (1.69)	3 (1.69)
No	7 (3.95)	9 (5.08)
Educational level[a], *n* (%)		
Lower	86 (48.59)	88 (49.72)
Higher	91 (51.41)	89 (50.28)
Employment status, *n* (%)		
Employed	143 (80.79)	144 (81.36)
Not employed	34 (19.21)	33 (18.64)
Country of birth, *n* (%)		
Netherlands	171 (96.61)	170 (96.05)
Outside Netherlands	6 (3.39)	7 (3.95)
Difficulty paying bills, *n* (%)		
Yes	13 (7.34)	14 (7.91)
Somewhat	90 (50.85)	85 (48.02)
No	74 (41.81)	78 (44.07)
BMI, *M* (*SD*)	26.18 (5.59)	26.03 (5.19)
Underweight, *n* (%)	2 (1.16)	3 (1.74)
Normal weight, *n* (%)	92 (53.18)	85 (49.42)
Overweight, *n* (%)	42 (24.28)	49 (28.49)
Obese, *n* (%)	37 (21.39)	35 (20.35)
Depressive symptoms, *M* (*SD*)	5.81 (4.52)	5.32 (4.04)
Child		
Age in months, *M* (*SD*)	9.67 (2.26)	10.03 (2.21)
Sex, *n* (%)		
Boys	97 (54.80)	89 (50.28)
Girls	80 (45.20)	88 (49.72)
First-born child, *n* (%)		
Yes	108 (61.02)	102 (57.63)
No	69 (38.98)	75 (42.37)
Ever breastfed, *n* (%)		
Yes	133 (75.14)	125 (70.62)
No	44 (24.86)	52 (29.38)
Breastfeeding duration in months, *M* (*SD*)	3.69 (4.03)	3.81 (4.23)
zBMI, *M* (*SD*)	−0.09 (1.03)	−0.08 (1.10)

[a]Parental educational level was dichotomized as lower (i.e., primary school, preparatory vocational education, vocational education) and higher educational level (i.e., pre-university and university).

(78.6%, 55/70). Reasons for deleting the app (reported at T2) were (multiple answers allowed): the app did not work properly (2.3%, 1/43), the app was not interesting (41.9%; 18/43), I needed to free up phone storage (20.9%, 9/43), and I got a new phone (39.5%; 17/43). A smaller number of parents still used the app a couple of times per month [22.9% (24/105) at T1, 15.7% (11/70) at T2] or per week [2.9% (3/105) at T1, 2.9% (2/70) at T2].

3.3.2. App use from database

Results from the database that collected data on parents' app use showed that parents started a total of 1,575 lessons and 406 challenges, of which 1,498 lessons (95.1%) and 381 challenges (93.8%) were completed. The number of lessons and challenges completed per parent in the app condition varied between 0 and 51 ($M = 10.46$, $SD = 13.56$). The mean number of lessons and challenges completed did not differ for parents with higher and lower educational level, as indicated by independent samples *t*-tests (p's > 0.05). Most lessons and challenges were completed in module 1 (51.9%, 975/1,879) and the number of completed lessons and challenges decreased with each subsequent module: 21.8% (410/1,879) in module 2, 15.4% (290/1,879) in module 3, 10.2% (192/1,879) in module 4, and 0.6% (12/1,879) in module 5. Based on child age at baseline, the maximum number of lessons and challenges that could be completed at T2 was either 51 (67.8%, 120/177) or 70 (32.2%, 57/177). At T2, 30.5% (54/177) of parents completed at least 25% of the available lessons and challenges, 13.0% (23/177) completed at least 50% of the available lessons and challenges, and only 4.0% (7/177) completed at least 75% of the available lessons and challenges. Most lessons and challenges were completed within the theme food (36.8%, 691/1,879), followed by drinks (21.9%, 412/1,879), sleep (14.0%, 263/1,879) and parent wellbeing (14.0%, 263/1,879), screens or physical activity (PA; 7.4%, 139/1,879), summary (5.1%, 96/1,879), and temper (0.8%, 15/1,879). Supplementary Table 1

TABLE 2 Pearson correlations between parent and child characteristics at baseline.

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Condition													
Parent													
2. Age	0.01												
3. Relationship to child[a]	0.00	0.07											
4. Romantic relationship[b]	−0.03	−0.04	0.03										
5. Educational level[c]	0.01	0.24***	0.06	−0.06									
6. Employment status[d]	−0.01	0.01	0.09	−0.21***	0.29***								
7. Born in the Netherlands[e]	−0.02	0.03	0.05	−0.04	0.01	−0.06							
8. Financial difficulty[f]	−0.02	0.10	0.03	−0.11*	0.33***	0.22***	0.01						
9. BMI	0.01	−0.16**	−0.04	−0.04	−0.28***	−0.13*	−0.06	−0.17***					
10. Depressive symptoms	0.06	−0.07	−0.14**	0.01	−0.11*	−0.17**	−0.05	−0.20***	0.07				
Child													
11. Age	−0.08	0.11*	−0.02	−0.03	0.08	0.14**	0.11*	0.09	−0.18***	−0.02			
12. Sex[g]	−0.05	0.06	0.04	−0.04	0.02	0.07	−0.01	0.07	0.01	−0.08	−0.01		
13. First born[h]	−0.03	0.21***	−0.03	−0.04	−0.08	−0.11*	−0.01	−0.08	−0.01	0.03	0.05	−0.02	
14. zBMI	0.00	−0.08	0.05	0.09	−0.02	−0.06	0.02	0.04	0.00	−0.01	0.13**	0.09	−0.07

Significance levels: *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
[a] 1, biological mother; 2, other caregiver.
[b] 1, in romantic relationship; 2, not in romantic relationship.
[c] 1, lower educational level; 2, higher educational level.
[d] 1, not employed; 2, employed.
[e] 1, born in the Netherlands; 2, born outside the Netherlands.
[f] 1, difficulty paying bills; 2, no difficulty paying bills.
[g] 1, boy; 2, girl.
[h] 1, first-born child; 2, not first-born child.

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shows the number of available lessons and challenges per module and per theme, the mean number of completed lessons and challenges per module and per theme, and the number of parents with access to each module at T0, T1, and T2.

3.4. App acceptability

Means and standard deviations for the self-reported rating (scales ranging from 1 to 7) of different aspects of the app at T1 and T2 are presented in Table 3. Parents gave statistically significant higher scores for design of the app at T1 than at T2. No other differences were found for the app acceptability items at T1 and T2. Although scores on ease of use were high for all parents, parents with lower educational level rated the app somewhat lower ($M = 5.02$, $SD = 1.77$) than parents with higher educational level ($M = 5.84$, $SD = 5.84$) regarding ease of use at T1 (but not at T2), $p = 0.003$. The other acceptability ratings at T1 and T2 did not differ for parents with lower and higher educational level (p's > 0.05). Overall, parents rated the app on average with a 6.60 (on a scale from 1 to 10) at both T1 and T2 (T1: $SD = 1.42$, T2: $SD = 1.50$), indicating moderate levels of acceptability of the *Samen Happie!* app. The average response to the question whether parents would recommend the app to others (on a scale from 0 to 10) was 5.80 ($SD = 2.30$) at T1 and 5.64 ($SD = 2.28$) at T2. The scores for app rating and intention to recommend did not significantly differ between T1 and T2 and did not differ for parents with lower and higher educational level, both at T1 and T2 (p's > 0.05).

3.5. Intervention effects on child zBMI

Tables 4, 5 present the results of the ITT analyses examining intervention effects on child zBMI using the non-imputed and imputed data. Table 4 shows that we found statistically significant and consistent main effects of time (both the shorter- and longer-term contrast) in all four analyses performed in the non-imputed and imputed data, indicating an increase in child zBMI over time and across conditions. Moreover, in the imputed data the two-way interactions between condition and both time contrasts (i.e., baseline vs. FU1 and baseline vs. FU2) were statistically significant. Table 5 presents the means and standard errors for child zBMI across conditions (i.e., overall intervention effect) and demonstrates that the increase in zBMI was greater in the control condition in the shorter-term, but greater in the app condition in the longer-term. These interactions did not emerge as statistically significant when using non-imputed data. Moreover, we found several statistically significant three-way interactions for subgroups based on parental educational level, BMI, and depressive symptoms in the imputed, but not the non-imputed data (see Table 4). First, we found interaction effects between parental educational level, condition, and both time contrasts. The estimated means in Table 5 show that in the shorter-term, zBMI increased the most among children of parents with lower educational level in the control condition and least among children of parents with lower educational level in the app condition. However, in the longer-term, the zBMI increases seemed more apparent in the app condition compared to the control condition, with the highest increases observed among children of parents with higher educational level. Second, there was an interaction between parental BMI, condition, and the longer-term time contrast. Table 5 shows that the longer-term increases in zBMI were highest in the app condition, particularly among children of parents with higher BMI. Third and finally, an interaction was observed between parental depressive symptoms, condition, and the longer-term time contrast. In the longer-term, zBMI increased in the app condition more than in the control condition, but children of parents with higher depressive symptoms in the control condition showed a similar increase in zBMI (see Table 5).

TABLE 3 Parent ratings of different aspects of the app at T1 and T2.

	T1 ($n = 122$)	T2 ($n = 113$)	
The app is...	*M* (*SD*)	*M* (*SD*)	*p*
Easy to use	5.48 (1.55)	5.53 (1.53)	0.426
Informative	4.48 (1.64)	4.50 (1.55)	0.656
Fast	5.33 (1.33)	5.31 (1.39)	0.264
Engaging	4.20 (1.56)	4.27 (1.73)	0.501
Nicely designed	5.38 (1.19)	5.11 (1.31)	**0.016**
Fulfilling my expectations	3.94 (1.51)	4.19 (1.48)	0.397
Making me feel confident	4.75 (1.19)	4.59 (1.24)	0.253
Useful	4.07 (1.51)	3.98 (1.76)	0.367
Clear	5.15 (1.21)	5.05 (1.36)	0.053
Helpful in my parenting	3.57 (1.56)	3.67 (1.78)	0.904

Ratings are on a scale from 1 to 7. Differences in ratings between T1 and T2 were tested using paired samples t-tests. Statistically significant comparisons ($p < 0.05$) are bolded.

3.6. Sensitivity analyses

To assess the robustness of the findings, the four models were tested again twice using both the non-imputed and imputed data: first, without multivariate outliers; and second, including only parents in the app condition who completed at least 1 lesson or challenge. In the non-imputed dataset, 17 multivariate outliers (i.e., cases with a Mahalanobis distance >14; this cut-off was based on a chi-square distribution with df

TABLE 4 Linear mixed model ITT intervention effects on child zBMI for subgroups based on parental educational level, BMI, and depressive symptoms in the non-imputed and imputed data.

	Non-imputed				Imputed			
	b	*SE*	95% CI	*p*	*b*	*SE*	95% CI	*p*
Overall intervention effect								
Condition	0.01	0.11	−0.21 to 0.24	0.937	0.06	0.09	−0.11 to 0.23	0.491
Shorter-term (baseline vs. FU1)	0.36	0.06	0.22–0.48	**<0.001**	0.40	0.01	0.38–0.42	**<0.001**
Longer-term (baseline vs. FU2)	0.39	0.07	0.26–0.54	**<0.001**	0.40	0.01	0.38–0.43	**<0.001**
Condition * shorter-term	−0.14	0.12	−0.36 to 0.12	0.257	−0.15	0.02	−0.20 to −0.11	**<0.001**
Condition * longer-term	0.17	0.14	−0.12 to 0.44	0.247	0.33	0.02	0.29–0.38	**<0.001**
Parental educational level								
Condition	0.01	0.11	−0.19 to 0.22	0.903	0.06	0.09	−0.10 to 0.27	0.468
Shorter-term (baseline vs. FU1)	0.36	0.06	0.24–0.48	**<0.001**	0.40	0.01	0.37–0.42	**<0.001**
Longer-term (baseline vs. FU2)	0.40	0.07	0.27–0.53	**<0.001**	0.40	0.01	0.38–0.43	**<0.001**
Parental educational level	−0.05	0.11	−0.25 to 0.17	0.620	−0.08	0.08	−0.25 to 0.08	0.325
Condition * shorter-term	−0.15	0.13	−0.41 to 0.09	0.229	−0.15	0.02	−0.20 to −0.11	**<0.001**
Condition * longer-term	0.15	0.14	−0.13 to 0.46	0.289	0.33	0.02	0.29–0.37	**<0.001**
Condition * parental educational level	−0.36	0.21	−0.77 to 0.06	0.092	−0.25	0.17	−0.59 to 0.09	0.145
Shorter-term * parental educational level	−0.09	0.13	−0.34 to 0.17	0.473	−0.10	0.02	−0.15 to −0.06	**<0.001**
Longer-term * parental educational level	0.10	0.14	−0.19 to 0.39	0.506	−0.00	0.02	−0.04 to 0.05	0.979
Condition * shorter-term * parental educational level	0.35	0.25	−0.14 to 0.86	0.166	0.37	0.05	0.28–0.46	**<0.001**
Condition * longer-term * parental educational level	0.07	0.29	−0.58 to 0.63	0.806	0.23	0.05	0.14–0.32	**<0.001**
Parental BMI								
Condition	0.01	0.11	−0.19 to 0.23	0.912	0.06	0.09	−0.11 to 0.23	0.502
Shorter-term (baseline vs. FU1)	0.36	0.06	0.24–0.47	**<0.001**	0.40	0.01	0.38–0.42	**<0.001**
Longer-term (baseline vs. FU2)	0.40	0.07	0.26–0.55	**<0.001**	0.40	0.01	0.38–0.43	**<0.001**
Parental BMI	0.01	0.01	−0.01 to 0.03	0.343	0.01	0.01	−0.01 to 0.02	0.313
Condition * shorter-term	−0.14	0.13	−0.41 to 0.11	0.254	−0.15	0.02	−0.19 to −0.11	**<0.001**
Condition * longer-term	0.17	0.14	−0.12 to 0.41	0.234	0.33	0.02	0.29–0.37	**<0.001**
Condition * parental BMI	0.02	0.02	−0.02 to 0.06	0.427	0.01	0.02	−0.02 to 0.04	0.477
Shorter-term * parental BMI	0.02	0.01	−0.01 to 0.04	0.189	0.02	0.00	0.01–0.02	**<0.001**
Longer-term * parental BMI	0.01	0.01	−0.02 to 0.03	0.641	0.01	0.00	0.01–0.02	**<0.001**
Condition * shorter-term * parental BMI	0.00	0.02	−0.04 to 0.06	0.934	−0.01	0.00	−0.02 to −0.003	0.058
Condition * longer-term * parental BMI	0.01	0.03	−0.04 to 0.07	0.619	0.01	0.00	0.001–0.02	**0.034**
Parental depressive symptoms								
Condition	0.00	0.11	−0.20 to 0.20	0.985	0.05	0.09	−0.12 to 0.22	0.544
Shorter-term (baseline vs. FU1)	0.36	0.06	0.24–0.48	**<0.001**	0.40	0.01	0.38–0.42	**<0.001**
Longer-term (baseline vs. FU2)	0.41	0.07	0.27–0.56	**<0.001**	0.41	0.01	0.39–0.43	**<0.001**
Parental depressive symptoms	0.01	0.01	−0.01 to 0.04	0.327	0.01	0.01	−0.01 to −0.03	0.151
Condition * shorter-term	−0.15	0.13	−0.38 to 0.09	0.243	−0.16	0.02	0.28–0.37	**<0.001**
Condition * longer-term	0.15	0.14	−0.11 to 0.45	0.285	0.32	0.02	−0.02 to 0.06	**<0.001**
Condition * parental depressive symptoms	0.02	0.03	−0.03 to 0.07	0.466	0.02	0.02	0.02–0.03	0.361
Shorter-term * parental depressive symptoms	0.02	0.02	−0.01 to 0.05	0.209	0.02	0.00	0.02–0.03	**<0.001**
Longer-term * parental depressive symptoms	0.02	0.02	−0.01 to 0.06	0.233	0.02	0.00	0.02–0.03	**<0.001**
Condition * shorter-term * parental depressive symptoms	0.01	0.03	−0.04 to 0.07	0.628	0.00	0.00	−0.01 to 0.01	0.814
Condition * longer-term * parental depressive symptoms	−0.03	0.03	−0.10–0.03	0.317	−0.04	0.00	−0.05–−0.03	**<0.001**

b, unstandardized regression coefficient; SE, standard error; CI, confidence interval. Parameter values for b and SE < 0.01 are presented as 0.00. Statistically significant effects ($p < 0.05$) are bolded.

= 3 and p = 0.003) and 56 parents who did not complete any lesson or challenge were excluded for the sensitivity analyses. The pattern of statistically significant results of the models did not change compared to the primary analyses when the non-imputed data were analyzed without multivariate outliers and when only the parents who completed at least 1 lesson or challenge were included.

For the sensitivity analyses performed in the imputed data (i.e., containing 20 simulations of the original dataset), ∼24 multivariate outliers per simulation (M = 24.35, SD = 3.50, range = 19–32) and a total of 56 parents who did not complete any lesson or challenge were excluded. In the analyses excluding multivariate outliers, the following two-way interactions were no longer significant: (1) the interaction between condition and the shorter-term time contrast in the model testing the overall intervention effect; (2) the interaction between condition and the shorter-term time contrast and the interaction between education and the shorter-term time contrast in the model testing the moderating effect of parental educational level; (3) the interaction between condition and the shorter-term time contrast in the model testing the moderating effect of parental BMI; and (4) the interaction between condition and the shorter-term time contrast in the model testing the moderating effect of parental depressive symptoms. The pattern of statistically significant three-way interactions (i.e., between condition, both time contrasts, and each of the moderators: parental educational level, BMI, and depressive symptoms) did not change compared to the primary analyses. Moreover, in the analyses including only parents who completed at least 1 lesson or challenge, no differences in the pattern of statistically significant effects were observed.

3.7. Exploratory analyses

To examine whether parents in the app condition (n = 177 in total) that were included in the adjusted PP analyses (n = 47) differed from parents who did not adhere to the criteria for higher app use (n = 130), a series of independent samples t-tests were performed in the non-imputed data. Parents who adhered to the criteria for higher app use were more likely to recommend the app to others (M = 6.45, SD = 1.97; on a scale from 1 to 10) than parents who did not adhere to these criteria (M = 5.14, SD = 2.31), $t_{(109)} = -3.03$, p = 0.003. Parents who adhered to the criteria for higher app use did not differ from parents who did not adhere to these criteria based on other app use characteristics (i.e., app rating, general app use, general skills in using apps, and subjective importance of apps), nor did they differ on several parent (i.e., age, educational level, financial difficulty, BMI, and depressive symptoms) and child (i.e., age, sex, being first-born, zBMI) characteristics (all p's > 0.05).

Tables 6, 7 present the results of the adjusted PP analyses examining intervention effects in the non-imputed and imputed data. The results of the adjusted PP analyses were mostly in line with the findings of the main ITT analyses. With respect to the overall intervention effect, similar main effects of both time contrasts and two-way interaction effects between condition and both time contrasts were found, using both the non-imputed and imputed data (see Table 6). With respect to the subgroup analyses based on parental educational level, BMI, and depressive symptoms, two differences in effects (using the imputed data) were observed in the adjusted PP analyses. First, unlike in the ITT analyses, the three-way interaction between parental educational level, condition, and the longer-term time contrast was no longer statistically significant in the adjusted PP analyses. Second, we found a statistically significant three-way interaction between parental BMI, condition, and the shorter-term time contrast in the adjusted PP analyses, that had not emerged as statistically significant in the ITT analyses. The estimated means and standard errors in Table 7 show that when comparing parents in the control condition to those in the app condition with higher app use, the increases in zBMI were greatest among children of parents in the control condition who had higher BMI. All other three-way interaction effects that were statistically significant in the ITT analyses (i.e., between parental educational level, condition, and shorter-term time contrast; parental BMI, condition, and the longer-term time contrast; and parental depressive symptoms, condition, and the longer-term time contrast) were observed in the same direction in the adjusted PP analyses and showed identical patterns of mean-level differences (see Table 7).

4. Discussion

This study investigated the process and effectiveness of the app-based parenting program *Samen Happie!* on child zBMI at 6 and 12-months follow-up. Process data showed that app acceptability was moderate, but that sustained app use was low. ITT analyses with imputed data revealed that zBMI increased in both conditions, but that this increase in zBMI was least pronounced in the app condition at the 6-month follow-up, particularly among children of parents with lower educational level. These effects were further supported by exploratory PP analyses focusing on parents with higher app use. In addition, adjusted PP analyses suggested beneficial shorter-term effects of higher app use for children of parents with higher BMI when compared with children of parents with higher BMI in the control condition. Despite these positive effects at the shorter-term follow-up, greater increases in zBMI were observed in the app condition at the 12-month follow-up in general. Overall, our findings suggest that the *Samen Happie!* app might prevent increases in zBMI of young children in the shorter-term, particularly among children of parents with lower educational level and parents with higher BMI who used the app more frequently, but that (even higher) app use

TABLE 5 Estimated means (ITT) for child zBMI at baseline, follow-up 1, and follow-up 2 for the app and control condition, specified by the levels (i.e., lower vs. higher) of parental educational level, BMI, and depressive symptoms in the non-imputed and imputed data.

	Non-imputed								Imputed							
	App condition				Control condition				App condition				Control condition			
Overall intervention effect																
	M		*SE*		*M*		*SE*		*M*		*SE*		*M*		*SE*	
Baseline	−0.08		0.08		−0.08		0.08		−0.08		0.06		−0.08		0.06	
Follow-up 1	0.21		0.10		0.35		0.09		0.24		0.06		0.39		0.06	
Follow-up 2	0.40		0.11		0.24		0.11		0.49		0.06		0.16		0.06	
Pairwise comparisons	Shorter-term (baseline vs. FU1) change in zBMI								+0.32**				+0.47**			
	Longer-term (baseline vs. FU2) change in zBMI								+0.57**				+0.24**			
Parental educational level																
	Lower edu.		Higher edu.		Lower edu.		Higher edu.		Lower edu.		Higher edu.		Lower edu.		Higher edu.	
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Baseline	0.08	0.12	−0.22	0.11	−0.18	0.12	0.02	0.12	0.06	0.09	−0.21	0.09	−0.17	0.09	0.01	0.09
Follow-up 1	0.33	0.14	0.11	0.13	0.39	0.14	0.32	0.13	0.34	0.09	0.15	0.09	0.45	0.09	0.34	0.09
Follow-up 2	0.49	0.16	0.31	0.14	0.11	0.15	0.37	0.15	0.57	0.09	0.41	0.09	0.13	0.09	0.19	0.09
Pairwise comparisons	Shorter-term (baseline vs. FU1) change in zBMI								+0.28**		+0.36**		+0.62**		+0.32**	
	Longer-term (baseline vs. FU2) change in zBMI								+0.51**		+0.62**		+0.31**		+0.18**	
Parental BMI																
	Lower BMI		Higher BMI		Lower BMI		Higher BMI		Lower BMI		Higher BMI		Lower BMI		Higher BMI	
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Baseline	−0.11	0.11	−0.05	0.11	−0.05	0.12	−0.11	0.12	−0.10	0.09	−0.06	0.09	−0.04	0.09	−0.12	0.09
Follow-up 1	0.09	0.14	0.34	0.14	0.30	0.14	0.41	0.14	0.14	0.09	0.34	0.09	0.31	0.09	0.47	0.09
Follow-up 2	0.30	0.15	0.52	0.17	0.26	0.16	0.21	0.16	0.38	0.09	0.59	0.09	0.16	0.09	0.15	0.09
Pairwise comparisons	Shorter-term (baseline vs. FU1) change in zBMI								ns		ns		ns		ns	
	Longer-term (baseline vs. FU2) change in zBMI								+ 0.48**		+0.65**		+ 0.20**		+0.27**	
Parental depressive symptoms																
	Lower depress.		Higher depress.		Lower depress.		Higher depress.		Lower depress.		Higher depress.		Lower depress.		Higher depress.	
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Baseline	−0.13	0.12	−0.03	0.11	−0.02	0.12	−0.14	0.12	−0.15	0.09	−0.02	0.08	−0.02	0.09	−0.15	0.09
Follow-up 1	0.05	0.13	0.37	0.13	0.36	0.14	0.35	0.15	0.07	0.09	0.37	0.08	0.37	0.09	0.41	0.09
Follow-up 2	0.34	0.15	0.47	0.14	0.14	0.15	0.35	0.17	0.41	0.09	0.54	0.08	0.05	0.09	0.28	0.09
Pairwise comparisons	Shorter-term (baseline vs. FU1) change in zBMI								ns		ns		ns		ns	
	Longer-term (baseline vs. FU2) change in zBMI								+0.56**		+0.56**		+0.07*		+0.43**	

Significance levels: *$p < 0.01$, **$p < 0.001$. Pairwise comparisons are presented only for significant interaction effects. (... 'or non-significant interactions are indicated by ns.

TABLE 6 Adjusted PP intervention effects on child zBMI for subgroups based on parental educational level, BMI, and depressive symptoms in the non-imputed and imputed data.

	Non-imputed				Imputed			
	b	*SE*	95% CI	*p*	*b*	*SE*	95% CI	*p*
Overall intervention effect								
Condition	−0.31	0.17	−0.62 to 0.01	0.065	−0.21	0.13	−0.47 to 0.05	0.115
Shorter-term (baseline vs. FU1)	0.27	0.09	0.08–0.46	**0.004**	0.40	0.02	0.36–0.43	**<0.001**
Longer-term (baseline vs. FU2)	0.37	0.10	0.19–0.58	**<0.001**	0.41	0.02	0.37–0.43	**<0.001**
Condition ∗ shorter-term	−0.31	0.19	−0.66 to 0.10	0.103	−0.15	0.03	−0.22 to −0.08	**<0.001**
Condition ∗ longer-term	0.11	0.20	−0.26 to 0.50	0.580	0.34	0.03	0.27–0.40	**<0.001**
Parental educational level								
Condition	−0.32	0.17	−0.65 to 0.03	0.053	−0.22	0.13	−0.48 to 0.04	0.095
Shorter-term (baseline vs. FU1)	0.27	0.10	0.09–0.44	**0.005**	0.40	0.02	0.37–0.43	**<0.001**
Longer-term (baseline vs. FU2)	0.37	0.10	0.13–0.56	**<0.001**	0.40	0.02	0.37–0.44	**<0.001**
Parental educational level	−0.17	0.17	−0.02 to 0.03	0.551	−0.17	0.13	−0.43 to 0.08	0.188
Condition ∗ shorter-term	−0.34	0.19	−0.68 to 0.04	0.092	−0.14	0.03	−0.22 to −0.08	**<0.001**
Condition ∗ longer-term	0.10	0.20	−0.35 to 0.52	0.730	0.33	0.03	0.26–0.40	**<0.001**
Condition ∗ parental educational level	−0.59	0.33	−0.04 to 0.07	0.556	−0.43	0.26	−0.94 to 0.09	0.104
Shorter-term ∗ parental educational level	0.03	0.19	−0.03 to 0.04	0.737	−0.11	0.03	−0.18 to −0.04	**0.002**
Longer-term ∗ parental educational level	−0.22	0.20	−0.02 to 0.05	0.395	−0.14	0.03	−0.21 to −0.07	**<0.001**
Condition ∗ shorter-term ∗ Parental educational level	0.59	0.38	−0.09 to 0.05	0.602	0.35	0.07	0.22–0.49	**<0.001**
Condition ∗ longer-term ∗ Parental educational level	−0.51	0.40	−0.04 to 0.08	0.394	−0.06	0.07	−0.19 to 0.08	0.422
Parental BMI								
Condition	−0.33	0.17	−0.19 to 0.23	0.051	−0.22	0.13	−0.48 to 0.04	0.100
Shorter-term (baseline vs. FU1)	0.27	0.10	0.24–0.47	**0.005**	0.40	0.02	0.36–0.43	**<0.001**
Longer-term (baseline vs. FU2)	0.35	0.10	0.26–0.55	**<0.001**	0.40	0.02	0.37–0.43	**<0.001**
Parental BMI	0.01	0.01	−0.01 to 0.03	0.551	0.01	0.01	−0.01 to 0.03	0.471
Condition ∗ shorter-term	−0.32	0.19	−0.41 to 0.11	0.254	−0.16	0.03	−0.23 to −0.09	**<0.001**
Condition ∗ longer-term	0.07	0.21	−0.12 to 0.41	0.234	0.32	0.03	0.25–0.39	**<0.001**
Condition ∗ parental BMI	0.02	0.03	−0.02 to 0.06	0.427	0.01	0.02	−0.03 to 0.05	0.619
Shorter-term ∗ parental BMI	0.01	0.02	−0.01 to 0.04	0.189	0.01	0.00	0.01–0.02	**<0.001**
Longer-term ∗ parental BMI	0.01	0.02	−0.02 to 0.03	0.641	0.01	0.00	0.01–0.02	**<0.001**
Condition ∗ shorter-term ∗ Parental BMI	−0.02	0.03	−0.04 to 0.06	0.934	−0.02	0.00	−0.03 to 0.004	**0.006**
Condition ∗ longer-term ∗ parental BMI	0.03	0.03	−0.04 to 0.07	0.619	0.01	0.00	0.0003–0.02	**0.045**
Parental depressive symptoms								
Condition	−0.32	0.17	−0.68 to 0.06	0.059	−0.21	0.13	−0.47–0.05	0.113
Shorter-term (baseline vs. FU1)	0.27	0.10	0.08–0.47	**0.004**	0.40	0.02	0.36–0.43	**<0.001**
Longer-term (baseline vs. FU2)	0.37	0.10	0.15–0.58	**<0.001**	0.41	0.02	0.37–0.44	**<0.001**
Parental depressive symptoms	0.00	0.02	−0.04 to 0.05	0.953	0.01	0.02	−0.02 to 0.04	0.611
Condition ∗ shorter-term	−0.32	0.19	−0.72 to 0.09	0.093	−0.15	0.03	−0.22 to −0.09	**<0.001**
Condition ∗ longer-term	0.09	0.21	−0.32 to 0.49	0.650	0.33	0.03	0.27–0.40	**<0.001**

(Continued)

TABLE 6 (Continued)

	Non-imputed				Imputed			
	b	*SE*	95% CI	*p*	*b*	*SE*	95% CI	*p*
Condition * parental depressive symptoms	−0.00	0.05	−0.09 to 0.08	0.961	0.01	0.03	−0.06 to 0.07	0.841
Shorter-term * parental depressive symptoms	0.02	0.03	−0.04 to 0.07	0.525	0.02	0.00	0.01–0.03	**<0.001**
Longer-term * parental depressive symptoms	0.01	0.03	−0.05 to 0.06	0.870	0.03	0.00	0.02–0.03	**<0.001**
Condition * shorter-term * parental depressive symptoms	0.01	0.06	−0.09 to 0.12	0.806	−0.01	0.00	−0.02 to 0.01	0.506
Condition * longer-term * parental depressive symptoms	−0.06	0.06	−0.18 to 0.04	0.272	−0.03	0.00	−0.05 to −0.02	**<0.001**

b, unstandardized regression coefficient; SE, standard error; CI, confidence interval. Parameter values for b and SE < 0.01 are presented as 0.00. Statistically significant effects ($p < 0.05$) are bolded.

does not appear to prevent increases in zBMI on the longer-term.

Across conditions, we found a general trend of increased zBMI over time in our sample of Dutch 0-to-2-year-olds, with increases from −0.09 at 10 months of age to 0.31 at 15.5 months, and to 0.39 at 23 months. Similar zBMI trajectories in this age group were observed in a Dutch (61) and a Canadian (62) study that used the same reference population (63). As such, patterns of increasing zBMI in this age group seem to be a common characteristic unspecific to our study.

The shorter-term finding that particularly children of parents with lower educational level and higher BMI (who used the app more frequently) profited most from the *Samen Happie!* program after 6 months, was in line with our hypotheses. However, these effects seemed to diminish at the longer-term, with the overall app condition showing higher zBMI values after 12 months compared to the control condition. Particularly shorter-term effects have been found before in digital preventive interventions for obesity [including interventions targeting children/adolescents and parents; (64)] and early interventions for high-risk infants (65). When looking specifically at mHealth parenting programs (i.e., using mobile systems such as apps, websites, and text messaging) for the prevention or treatment of childhood obesity, a recent review found mostly no effects on child zBMI (also not at the shorter-term), however, these studies mainly included older children (66). One app-based program among preschoolers (MINISTOP) that was included in this review showed effects on a composite score including fat mass index and dietary and physical activity variables after 6 months [but not fat mass only at 6 months; (67)], but these effects were not retained at the 12-month follow-up (68). We identified only one other app-based parenting program for obesity prevention [Growing Healthy; not included in review (66)] that examined weight outcomes in infants, finding no effects on child zBMI, however, children in this study were somewhat younger at follow-up (69). Overall, our findings are in line with these previous findings suggesting that the effects of mHealth parenting programs on child weight status to date may be limited and fading over time.

We do not have an explanation for these longer-term fading effects, other than speculating about potential rebound effects when app use decreased over time. Of note, decreased app use probably forms the most important explanation for the finding that children of parents with lower educational level and higher BMI (that use the app more frequently) seem to have shortly profited from the app, but not on the longer-term. Importantly, process data indicated that most app use—even among parents who used the app more frequently—occurred at the shorter-term (i.e., between baseline and the 6-month follow-up), which supports the notion that active, sustained use of the app is probably needed for longer-term effects to establish. Additionally, our process data indicated that parents completed relatively more lessons than challenges, and that even among the more frequent app users, only two-thirds of parents completed at least half of the challenges. Whereas, the lessons focused primarily on enhancing knowledge and attitudes through behavior changes techniques like consciousness raising and framing, the challenges were designed to facilitate the transfer of this knowledge into regular daily habits [e.g., through implementation intentions; see (40)]. Hence, longer-term effects may depend on parents using the app, and particularly the challenges, more intensely.

Our findings suggest that engaging frequently with an app is important for the effectiveness of app-based programs [see also the review by Rossiter et al. (65)]. Although we deliberately gave no instructions regarding the timing and frequency of app use with the goal to mimic actual program adherence in real life, this might have resulted in the observed patterns of declining and generally low app use. A pattern of decreasing app use within the first weeks is frequently observed in app-based health interventions (70) and might be caused by a drop in engagement when the novelty of the app wears off (71). The moderate levels of app acceptability in combination with parents reporting to use the app mainly after installing it (but not frequently anymore after that), indicate that our results are in line with these previous findings. A recent review among a broad range of app-based health programs showed that the programs with the highest user engagement were

TABLE 7 Estimated means (adjusted PP) for child zBMI at baseline, follow-up 1, and follow-up 2 for the app and control condition, specified by the levels (i.e., lower vs. higher) of parental educational level, BMI, and depressive symptoms in the non-imputed and imputed data.

	Non-imputed								Imputed							
	App condition				Control condition				App condition				Control condition			
Overall intervention effect																
	M		*SE*		*M*		*SE*		*M*		*SE*		*M*		*SE*	
Baseline	−0.32		0.16		−0.08		0.08		−0.35		0.12		−0.08		0.06	
Follow-up 1	−0.20		0.19		0.35		0.09		−0.03		0.12		0.39		0.06	
Follow-up 2	0.10		0.20		0.23		0.10		0.23		0.12		0.16		0.06	
Pairwise comparisons					Shorter-term (baseline vs. FU1) change in zBMI				+0.32**				+0.47**			
					Longer-term (baseline vs. FU2) change in zBMI				+0.58**				+0.24**			
Parental educational level																
	Lower edu.		Higher edu.		Lower edu.		Higher edu.		Lower edu.		Higher edu.		Lower edu.		Higher edu.	
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Baseline	−0.12	0.22	−0.54	0.22	−0.18	0.12	0.02	0.11	−0.18	0.16	−0.54	0.17	−0.17	0.09	0.01	0.09
Follow-up 1	−0.18	0.29	−0.28	0.25	0.39	0.13	0.32	0.13	0.11	0.16	−0.18	0.17	0.45	0.09	0.34	0.09
Follow-up 2	0.54	0.28	−0.35	0.28	0.12	0.14	0.35	0.14	0.47	0.16	−0.05	0.17	0.13	0.09	0.19	0.09
Pairwise comparisons					Shorter-term (baseline vs. FU1) change in zBMI				+0.28**		+0.36**		+0.62**		+0.32**	
					Longer-term (baseline vs. FU2) change in zBMI				ns		ns		ns		ns	
Parental BMI																
	Lower BMI		Higher BMI		Lower BMI		Higher BMI		Lower BMI		Higher BMI		Lower BMI		Higher BMI	
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Baseline	−0.37	0.21	−0.28	0.19	−0.05	0.12	−0.10	0.12	−0.38	0.16	−0.33	0.14	−0.04	0.09	−0.12	0.09
Follow-up 1	−0.24	0.26	−0.19	0.26	0.30	0.14	0.41	0.13	−0.09	0.16	0.03	0.14	0.31	0.09	0.47	0.09
Follow-up 2	−0.14	0.28	0.24	0.24	0.26	0.16	0.21	0.15	0.09	0.16	0.33	0.14	0.16	0.09	0.15	0.09
Pairwise comparisons							Shorter-term (baseline vs. FU1) change in zBMI		+0.28**		+0.30**		+0.27**		+0.59**	
							Longer-term (baseline vs. FU2) change in zBMI		+0.47**		+0.66**		+0.20**		+0.27**	
Parental depressive symptoms																
	Lower depress.		Higher depress.		Lower depress.		Higher depress.		Lower depress.		Higher depress.		Lower depress.		Higher depress.	
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Baseline	−0.33	0.24	−0.32	0.23	−0.02	0.11	−0.14	0.12	−0.37	0.18	−0.33	0.17	−0.02	0.09	−0.15	0.09
Follow-up 1	−0.32	0.31	−0.10	0.31	0.37	0.13	0.35	0.14	0.11	0.18	0.05	0.17	0.37	0.09	0.41	0.09
Follow-up 2	0.21	0.31	−0.01	0.32	0.15	0.15	0.35	0.16	0.16	0.18	0.27	0.17	0.05	0.09	0.28	0.09
Pairwise comparisons							Shorter-term (baseline vs. FU1) change in zBMI		ns		ns		ns		ns	
							Longer-term (baseline vs. FU2) change in zBMI		+0.53**		+0.60**		+0.07*		+0.43**	

Significance levels: $*p < 0.01$, $**p < 0.001$. Pairwise comparisons are presented only for significant interaction effects. [illegible] or non-significant interactions are indicated by ns.

primarily characterized by the option to receive (particularly personalized) push notifications, easy access to information, and the ability to communicate with health professionals (70). Although our participants were able to receive personalized push notifications for the challenges, this feature could have been made stronger if we had used it regularly (e.g., weekly) as a reminder for lessons and challenges that parents had not yet completed. Moreover, access to the information in our app was relatively easy through the age- and theme-based content, but our process data suggested that some parents would prefer a solely theme-based structure organized around child EBRBs (e.g., dietary intake, sleep) over the overarching age-based modules. From an engagement perspective, a potential downside of the age-based modules might have been that parents could not explore content for the next developmental stages of their child until their child reached the minimum age of that level. This might have impeded the eagerness of interested and motivated parents as well as potential positive anticipatory guidance [i.e., proactive advice effects (72, 73)]. Lastly, our app offered parents digital parenting support without the option for direct communication with health professionals, whereas additional support in the form of (offline) health-professional led support groups might have increased engagement (74, 75). Strategies combining easily accessible parenting apps with additional (offline) support might be particularly helpful to stimulate longer-term benefits of the *Samen Happie!* app among at-risk families that need more tailored parenting support. Future research should corroborate whether these strategies match parents' preferences for app-based parenting programs and whether they can stimulate parental engagement over longer periods of time.

4.1. Limitations and directions for future research

Several strengths of this study should be noted, including that it was pre-registered, conducted in a representative sample of Dutch adults (aged 25– 45 years) in terms of educational level (76), and had high retention rates (almost 90% at 12-month follow-up). Nevertheless, the study also has limitations. First, although the patterns of results in the imputed and non-imputed data were largely similar, we only found statistically significant effects in the imputed data. Even though the quality of the imputed values was good and most findings were corroborated in the exploratory PP analyses, the results need to be interpreted with caution and confirmed by future studies. That findings were not statistically significant when using the non-imputed data might be due to the loss of statistical power caused by the high number of missing values in child zBMI (64% at 12-month follow-up). To increase the validity of the data, we asked parents to report child height and weight as measured at the preventive child health clinic, but this resulted in a great deal of missingness because children were only measured at specific time points. Missingness in child zBMI did not depend on characteristics other than child age and the chances of bias are therefore low, but the high number of missingness could have posed power issues to detect effects. Future studies should line up the assessment of child height and weight with visits to the preventive child health clinic to ensure complete anthropometric outcome data.

Second, we examined child zBMI as primary and sole outcome. Although zBMI is a sex- and age-specific measure, the wide age range at baseline (5–15 months) might have potentially influenced our results, but we were unable to test this due to power restrictions. The use of zBMI to measure weight status in infancy is recommended by pediatric societies (77, 78) and this measure shows consistent links with adiposity in childhood (62), however, some have argued that BMI alone does not provide the best indication of adiposity [e.g., (79)]. Particularly in the first years of life, rapid changes in body composition (e.g., fluid balance) can result in changes in fat (free) mass, and these processes can vary greatly between children (80). Moreover, intervention-induced changes in healthy EBRBs might not always be visible through changes in BMI (79), particularly in interventions shorter than 12 months (81). Together with the complexity of infant weight development, this emphasizes the need to assess other outcomes related to children's energy balance, such as dietary intake, sleep, and physical (in)activity in addition to zBMI.

Third, although parental educational level is a frequently used indicator of family SEP in pediatric health research (82), it was the only indicator of SEP we used in this study. There might be other relevant socioeconomic factors that also play a role in child health outcomes, such as family income, parental employment, and the neighborhood a family lives (83, 84). As associations between indicators of SEP can be low (85, 86), each of those indicators individually as well as the interaction between indicators could importantly influence a family's SEP and is therefore interesting to investigate in future parenting research.

Fourth, although our sample was representative in terms of parental educational level, the sample was homogeneous in terms of ethnicity, with more than 95% of parents being born in the Netherlands. However, no other indicators of cultural background were assessed such as religion or language(s) spoken at home, whereas such factors might have affected program engagement and effectiveness (87). Future obesity prevention programs should recruit a diverse population of participants in terms of ethnic and cultural background. Additionally, programs should consider recruiting first-time parents in particular given that these parents might have a higher need for parenting support, as indicated by the higher levels of engagement of first-time parents in a healthy feeding intervention (88).

Fifth and finally, only primary caregivers participated in this study, which were primarily mothers (>95%). However, other caregivers might also be involved in energy balance-related parenting, such as fathers (89) and grandparents [who might even promote unhealthy dietary intake and weight status; (90)]. As one third of infants in a Dutch study was cared for by others (e.g., grandparents, daycare) for more than 20 h per week (61), it is important that future preventive interventions for childhood obesity also target other caregivers that are involved in energy balance-related parenting.

Conclusion

In conclusion, this study showed that the app-based parenting program *Samen Happie!* might be effective in preventing increases in infant zBMI after 6 months, particularly among children of parents with lower educational level and children of parents with higher BMI who use the app more frequently. Despite these promising effects at the shorter-term, however, greater increases in zBMI were observed among children of parents who used the app after 12 months. Future research should be directed at replicating the positive effects found after 6 months and at finding ways to extend these effects to the longer-term. To this end, it is imperative to determine what is needed to stimulate sustained app use and engagement in mHealth parenting programs for childhood obesity and how these programs can be complemented with additional (offline) support for high-risk families in particular.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: https://osf.io/wcsxg/ (Open Science Framework).

Ethics statement

The studies involving human participants were reviewed and approved by the Ethics Committee of the Faculty of Social Sciences, Radboud University, the Netherlands. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

JL, LK, JV, CW, RH, ER, and SK contributed to the conceptualization of the study and development of the *Samen Happie!* program. LK, JL, JV, and CW developed the questionnaires. LK managed data collection. LK with input from WB, performed data analyses. LK drafted the paper, on which all authors provided critical feedback. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.1012431/full#supplementary-material

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Momentary predictors of a broad range of food parenting practices within a population-based sample of parents of preschool-aged children

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Introduction: The current study sought to understand the influence of momentary factors within the home and family environment, including parent stress, parent and child mood and child behaviors, on parents' use of a broad range of food parenting practices later that same day.

Methods: Ecological Momentary Assessment (EMA) was used to evaluate parents' use of coercive, indulgent, structured and autonomy support food parenting practices, as well as numerous potentially salient momentary predictors, including parental stress, parent and child mood, and child behavior. Data were collected from 109 parents of preschool aged children multiple times per day over the course of a ten-day data collection period, allowing for temporal sequencing of momentary predictors and use of food parenting practices.

Results: With some notable exceptions, study findings align with study hypotheses in that parent stress, parent and child low mood, and child negative behaviors early in the day were found to be associated with the use of less supportive food parenting practices later that same day. For example, greater parent negative mood earlier in the day was associated with a decrease in use of feeding practices from within the structure domain later on that same day (-2.5%, $p < 0.01$), whereas greater parent positive mood earlier in the day was associated with an increase in use of structure later on that same day ($+3.7\%$, $p < 0.01$). Greater parent stress earlier in the day was associated with an increase in the use of coercive control ($+3.2\%$, $p < 0.01$) and indulgent ($+3.0\%$, $p < 0.01$) practices later that same day; surprisingly, a similar increase in stress earlier in the day was also found to be associated with an increase in the use of autonomy support (5.6%, $p < 0.01$) feeding practices later on that same day.

Discussion: Developing an understanding of the types of momentary factors that influence a parent's use of particular food parenting practices across multiple contexts is a crucial next step toward developing effective interventions aimed at teaching parents to use food parenting practices that are supportive of healthful child dietary intake and eating behaviors in a way that is responsive to shifting factors.

KEYWORDS

food parenting practices, preschool-aged child, ecological momentary assessment (EMA), stress, mood, child behavior

Introduction

Healthful eating patterns and dietary intake during early childhood are important for growth and development and for the long-term prevention of health concerns (1). Children's eating behaviors and dietary intake are shaped significantly by their family and home food environment (2–5). Parents use a broad range of food parenting practices, or goal-oriented actions and behaviors to shape and socialize their children's eating behaviors and dietary intake (2, 6–9). For example, a parent might engage in food restriction (i.e., limiting the types or amounts of foods their child can eat) with the goal of helping them to avoid overconsumption of certain foods, or a parent might engage in pressure-to-eat feeding practices in response to challenges associated with feeding their child that struggles with pickiness. Food parenting practices encompass a range of behaviors that dictate what foods are made available and accessible to their child, as well as the nature and tone of interactions with children around food (2, 9). The current research study draws from a leading conceptual framework of food parenting, developed by Vaughn and colleagues, which describes three higher-level domains of practices: structure, such as food availability, accessibility, and limit setting; autonomy support, such as praise and reasoning; and coercive control, such as pressure-to-eat and overt food restriction (2, 9). Indulgence has been proposed to be either a sub-domain of structure (2), or a fourth unique high-level domain of potential importance (6); indulgent behaviors allow children greater freedom over what, when, and how much to eat. Current theory and research to date suggest that food parenting practices within the structure and autonomy support domain are "supportive" and those practices within the coercive control and indulgent domain are "unsupportive" of healthful dietary intake and eating behaviors in children (2–5). However, empirical evidence to support the impact of food parenting practices within the structure and autonomy support domains on child outcomes is much more limited than the evidence-base examining the short- and long term impacts of coercive control practices (2–5, 9). For example, many structure and autonomy support food parenting practices have received little [e.g., guided choices (2)] or no [e.g., food preparation (2)] attention in prospective studies, (2, 5) with other structure practices having a much deeper evidence base (e.g., food accessibility, availability, modeling) (4, 5).

There is a large body of literature that indicates that high levels of parental stress and parental depressed mood are associated with a parent's own unhealthy dietary intake and less healthful food preparation (10, 11). Less is known about how the relationship between parental stress and mood and parental use of specific food parenting practices (12). A small number of research studies published in the extant literature have revealed associations between maternal depressed mood and use of pressure-to eat feeding practices (13) and maternal stress and use of controlling food parenting practices (12), suggesting that these individual parent-level factors do influence parent's engagement in food parenting practices. However, although experts generally agree that food parenting practices are goal-directed behaviors sensitive to circumstance, previous studies have only typically assessed parents' "usual" use of food parenting practices *via* questionnaires, failing to account for potentially important variation in use of specific food parenting practices across time and contexts (2, 8). For example, a parent might report *via* survey their "usual" use of coercive feeding practices is low or infrequent, but on days when their stress level is particularly high or their child's eating behaviors are highly challenging, they might pressure children to eat particular foods or place greater restrictions on children's eating. Indeed, our recent research provides new preliminary evidence that food parenting practices show significant within- and between-day variation that is shaped by a wide range of momentary influences encountered in everyday family life (6, 14, 15). Specifically, in our prior qualitative research parents of preschoolers described a number of momentary factors that influenced their use of specific food parenting practices: parent mood or stress level, child mood, behavior or physical health, time constraints, lack of planning, and/or competing priorities (e.g., other children, job requirements, activities or special events) (6). Importantly, parents in this study described shifts from the use of structure- and autonomy support- feeding practices to more indulgent and controlling practices in the face of external challenges highlighting the need for more nuanced approaches to investigating potential sources of within- and across-day variation in food parenting practices. Findings from this study (6) support the premise that challenges experienced early on-, and throughout- the day contribute to a parent's differential use of specific food parenting practices at shared meals later in the day. While not directly examined within this qualitative study, it seems that external challenges leading to parents running out of time, patience, or energy might be contributing factors to the shift in approach described.

Recent evidence on temporal relationships between these momentary variables (e.g., stress, child behavior) and use of food parenting practices provides some support for this perspective (16, 17). Indeed, two recent publications by Berge and colleagues provided preliminary quantitative evidence of these momentary (i.e., within- or between-day) shifts in food parenting practices through the use of Ecological Momentary Assessment (EMA) (16, 17); EMA uses short surveys delivered to hand-held devices in real time throughout the day to capture dynamic changes in behaviors across time and context (18). Specifically, Berge and colleagues found that high levels of parental stress, as well as parental depressed mood, earlier in the day were found to predict greater use of coercive control feeding practices later the same day (16, 17). This preliminary work demonstrates that momentary influences experienced early in the day can shift parents' engagement to food parenting practices that are unsupportive and associated with higher risk of poor dietary intake over time. That said, little is known about how various momentary factors, including child-related factors (e.g., child mood, behavior) influence the within-day variability in parents' use of food parenting practices that fall within the structure-, autonomy support-, and indulgent- higher-order domains (15).

Thus, the current study seeks to build upon and extend this early work by seeking to understand how parent and child mood, parent stress, and child behaviors early in the day are associated with parent use of a broad range of specific food parenting practices, situated within four higher order domains (structure, autonomy support, indulgent, coercive control), later that same day. Furthermore, the current sample includes young children ages 2–5, whereas, Berge's studies included children ages 59 (16, 17). Thus, the current study advances the science of examining momentary predictors of food parenting with preschool children. Based on findings from our previous qualitative work with parents of young children (6), we hypothesized that greater negative mood (parent and child), high stress, and negative child behavior early in the day would be associated with greater use of coercive control and indulgent food parenting practices later on that same day, whereas greater positive mood (parent and children), lower stress, and positive child behavior early in the day would be associated with greater use of structure and autonomy support food parenting practices later on that same day. To our knowledge this is the first study to examine the impact of multiple momentary influences (parent- and child-level) on the use of such a broad range of food parenting practices, including practices from across the four higher-order domains most commonly discussed in current conceptual models of food parenting practices (structure, autonomy support, coercive control, indulgence) with preschool children, within a sample of preschool-parent dyads. Findings from our research studies to date underscore the importance of considering food parenting practices as context specific and responsive to changes in the home environment, including stress and mood. Developing an understanding of the types of momentary factors that influence a parent's use of particular food parenting practices across multiple contexts is a crucial next step toward the development of just-in-time adaptive interventions, or interventions that aim to deliver intervention content to participants' mobile devises in response to real-time assessments of context, behavior and circumstance. Long term, findings the from the current study will inform the design of just-in-time adaptive interventions developed with the goal of improving children's dietary intake and eating patterns and consequently reducing the morbidity and mortality associated with chronic disease across the life span.

Materials and methods

Study design and population

Data for the present study are from Kids EAT!, mixed-methods observational study designed to deepen our understanding of parents' experiences feeding their preschool-aged child and the factors that influence their decisions about feeding (14). Kids EAT! study participants ($n = 116$) completed traditional questionnaires about demographics, family routines and functioning, and child feeding and eating behaviors *via* online surveys, followed by 10 days of ecological momentary assessment (EMA) completed *via* cell phone during the fall of 2019. The current study only uses data from the EMA data collection protocol.

Study population, recruitment, and participant demographics

Kids EAT! (14) is an ancillary study to EAT 2010–2018 (Eating and Activity among Teens) (19) a large, population-based cohort study on eating and weight-related health. Survey data collected from 1,491 young adults (Mean age 22.2) as a part of EAT 2018 were utilized to identify potential Kids EAT! participants that met the inclusion criteria; young adults who indicated on the EAT 2018 survey that they had at least one child aged 2–5 years who lived with them at least 50% of the time were invited by email to participate in the Kids EAT! study. Participants in the original EAT 2010–2018 cohort lived in the Minneapolis—Saint Paul metropolitan area during their initial participation in 2010; eligible participants were invited to participate in Kids EAT! regardless of their current geographic location at the time of data collection for this study. Kids EAT! recruitment e-mails indicated that the study goal was to learn more about parents' experiences feeding their pre-school aged child and provided some information about study data collection procedures. The University of Minnesota's Institutional Review Board Human Subjects Committee approved all protocols used for the Kids EAT! study.

Table 1 provides demographic information on the sample. The participating parents ($n = 109$) had a mean age of 26.4 at the time of survey completion. Just over half of participants (56%) reported education beyond high school. Approximately 21.1% of the sample reported household incomes below the 2020 Federal Poverty line for household sizes of 2 or more individuals ($17,420) (20).

Procedures and data collection

Participants completed the Kids EAT! baseline survey online, using an individualized link included in the study recruitment e-mail. The survey included questions on a wide range of topics including demographics, family routines and functioning, and child feeding and eating behaviors. Next, parents were given detailed instructions for how to complete the EMA protocol. The 10-day EMA data collection period began the day following survey completion. Standardized EMA data collection protocols from prior studies (18, 21, 22) were used to guide the development of EMA-based *Real-Time Feeding Practices* survey (14) and sampling methods.

During the EMA data collection period, parents were asked to complete surveys in response to three types of EMA sampling methods: (1) signal-contingent, (2) event-contingent, and (3) end-of-day EMA surveys. Parents completed all EMA recordings using their own electronic device (i.e., cell phone, tablet) using a link provided to them *via* SMS text message. On average, each EMA recording took participants 2–3 min to complete.

Parents were sent four signal-contingent surveys per day. Signal-contingent surveys were spaced so they began after the parent woke up (information provided prior to starting EMA). The time between the parents' reported wake and sleep times was divided into five blocks to accommodate the semi-random scheduling of 4 signal-contingent surveys and the end-of-day survey, with at least 1 h separating each block (e.g., a block of time from 8 to 11 AM with the next block starting at noon), so that there would never be an overlap of surveys. Scheduling signal-contingent surveys around the parents sleep and wake time allowed surveys to be scheduled to accommodate different life situations (e.g., working an overnight shift), if needed. Parents were notified *via* SMS text message that a signal contingent survey was ready to be taken; they would click the link provided which would take them to a secure web-based survey. Signal contingent surveys measured parent stress, parent and child mood, and child behavior. Specific measures used in analysis for the current study are described in detail below.

Event-contingent surveys were self-initiated by parents whenever the child ate in the presence of the parent (i.e., both meals and snacks); importantly, parents did not need to be sitting and eating with the child to complete a recording, they were only required to be present to the degree that they felt they could respond to the questions specific to the eating occasion. It was important to have parents fill out the EMA response even when they were not eating with their child because parents often still engage in food parenting practices in this situation. To initiate an event-contingent survey parents clicked on a link provided to them *via* SMS message; this link remained the same throughout the EMA data collection period allowing parents to use the same link throughout the full study period to respond to all event-contingent recordings. Knowing that participants might forget to report a shared eating occasion, at the start of each signal-contingent survey they were asked about—and given the opportunity to report on—any shared eating occasions that they may have failed to report on. Event contingent recordings asked parents to report on details of the eating occasion that prompted the recording, including their use of specific food-related parenting practices. Specific measures used in analysis for the current study are described in detail below.

A link to complete the end-of-day survey was provided to parents *via* SMS text message in the hour prior to their reported typical sleep time. Data from end-of-day surveys were not used for the current analysis so they are not described in further detail.

All EMA surveys were completed in English; participants' English language fluency was determined during their initial enrollment in the EAT 2010–2018 study. Families were offered an incentive of a $150 gift card for participation in the Kids EAT! Study. Data collection was completed on all participants between October 2019 and February 2020.

Measures

Food parenting practices were measured during EMA event-contingent surveys using the EMA-based Real-time Parent Feeding Practices survey tool (14). This tool was developed for the Kids EAT! Study, based on prior validated measures if available, to measure a broad range of food-related parenting practices within an EMA protocol. The survey includes 22 questions on food-related parenting practices situated within four higher-order theoretical domains, including Coercive Control (5 items), Indulgent (3 items), Structure (5 items), Autonomy support (9 items); the language for each individual measure is included in Table 2. Existing questionnaires including the Child Feeding Questionnaire (8) and the Food Parenting Inventory (23) were used where possible to adapt individual questions for use within an EMA protocol. For example, an

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TABLE 1 Study demographic characteristics ($n = 109$).

		n
Parent gender	Female	91 (83.5)
	Male	18 (16.5)
Parent race/ethnicity	Black	35 (32.1)
	Hispanic	26 (23.9)
	Asian	19 (17.4)
	White	16 (14.7)
	More than one race/other	9 (8.3)
	Native American	4 (3.7)
Parent education	Partial high school or less	11 (10.1)
	High school graduate or GED	37 (33.9)
	Partial college or specialized training	39 (35.8)
	College graduate	19 (17.4)
	Graduate degree	3 (2.8)
Spouse education	Partial high school or less	10 (9.2)
	High school graduate or GED	31 (28.4)
	Partial college or specialized training	22 (20.2)
	College graduate	9 (8.3)
	Graduate degree	5 (4.6)
	No spouse/not applicable	32 (29.4)
Household income	$0–$9,999	16 (14.7)
	$10,000–$14,999	7 (6.4)
	$15,000–$24,999	20 (18.3)
	$25,000–$34,999	21 (19.3)
	$35,000–$49,999	16 (14.7)
	$50,000–$74,999	20 (18.3)
	$75,000–and above	9 (8.3)

item on the Child Feeding Questionnaire designed to measure parental pressure to eat reads, "I have to be especially careful to make sure my child eats enough". This question was adapted for use within an EMA protocol to focus on a parent's specific behavior at the most recent meal or snack consumed by their child. The adapted question read, "Thinking of this meal or snack, did you have to encourage your child to eat more food than they wanted to?". Parents responded yes/no for each item, following each eating occasion they shared with their child. Additional details on the development of this survey tool have been previously published (14).

Parent stress was assessed during signal-contingent EMA surveys by the following 10 items developed based on previous qualitative findings of momentary impacts on food parenting practices (6) and rated on a 5-point Likert scale (1-very slightly or not at all to 5-extremely): Felt like I didn't have enough time to get everything done that I needed to; Busy with a number of work or household activities; Busy with family or friend activities; Occupied by a special event; Down, sad or depressed; Stressed out; Worn out, tired or exhausted; Sick or under the weather; Constantly on-the-go; Disrupted by unexpected changes to my plan or routine. A total score was calculated as the sum of item scores; possible scores ranged from 10 to 50.

Parent mood (i.e., Negative and Positive Affect) was each assessed during signal-contingent EMA surveys by 20 items adapted from the short form of the Positive and Negative Affect Scale (PANAS) (24) for use within an EMA protocol (25) and rated on a 5-point Likert scale (1-very slightly or not at all to 5extremely). Negative Affect (10 items) included: Distressed, Upset, Guilty, Scared, Hostile, Irritable, Ashamed, Nervous, Jittery, Afraid. Positive Affect (10 items) included: Interested, Excited, Strong, Enthusiastic, Proud, Alert, Inspired,

TABLE 2 Individual items from the EMA-based real-time parent feeding practices survey.

High level feeding domain	Specific feeding behavior
	Thinking about this meal or snack, did you….(Response options yes/no)
Structure	
	Sit and eat with your child
	Choose where your child ate the meal or snack
	Choose what foods your child got to eat
	Closely monitor the type and amount of food eaten by your child
	Allow your child to choose what to eat, from several options you had already picked out
Autonomy support	
	Involve your child in deciding what foods they would eat
	Allow your child to take seconds if they asked for them
	Teach your child about why you wanted them to eat more of certain foods
	Teach your child about why you wanted them to eat less of certain foods
	Tell your child you wanted them to eat more of certain foods
	Encourage your child to try at least a small amount of all foods offered
	Negotiate with your child about how much food they needed to eat
	Negotiate with your child about what foods they needed to eat
	Tell your child you wanted them to eat less of certain foods
Coercive control	
	Have to encourage your child to eat more food than they wanted to
	Offer your child a treat or reward for eating more
	Have to make sure your child did not eat too much food
	Offer your child a treat or reward for trying a new food
	Trick or bribe your child into eating more than they wanted to
Indulgent	
	Choose to prepare separate food that knew your child would enjoy eating
	Allow your child to choose a separate meal or different food because they did not want to eat what was offered
	Give your child food in order to calm them down or help manage their behavior

Parents were asked to use their cell phone to respond to this survey following each of their child's eating occasions for which they were present for a data collection period of 10 days. Additional details included in the measures section of the manuscript.

Determined, Attentive, Active. A total score for each scale was calculated as the sum of item scores; possible scores ranged from 10 to 50.

Child Mood (i.e., Negative and Positive Affect) was assessed during signal-contingent EMA surveys by asking parents to report on their child's mood using a total of 8 items adapted from the PANAS-C (26) for use within an EMA protocol and rated on a 5-point Likert scale (1-very slightly or not at all to 5-extremely). Positive Affect (4 items) were Happy, Joyful, Excited, and Energetic. Negative Affect (4 items) included Sad, Angry, Nervous, and Upset. A total score for each scale was calculated as the sum of item responses; possible scores ranged from 4 to 20.

Child positive behaviors and negative behaviors were assessed during signal-contingent EMA surveys by asking parents to report on their child's behavior using 7 items developed based on previous qualitative findings of momentary impacts on food parenting practices (6) and rated on a 5-point Likert scale (1-very slightly or not at all to 5 extremely). Positive Behaviors (2 items) were Well-behaved and Agreeable/Easy Going. Negative Behaviors (5 items) were Getting into trouble/Acting Out; Crabby; Fussy/Whiny; Out-of-control; Having a hard time sitting still/Hyper/Overly-energetic. A total score for each scale was calculated as the sum of item scores; possible scores for Positive Behaviors ranged from 2 to 10 and possible scores for Negative Behaviors ranged from 5 to 25.

Demographics. Child- (e.g., age, sex), parent- (e.g., age, sex, educational attainment), and family level (e.g., income, family structure) demographic characteristics were assessed via questions on the Kids EAT! baseline survey (14).

Data analysis

To evaluate temporal ordering, data collected from EMA event prompts (i.e., participant initiated survey of food parenting practices used at specific eating occasions) were paired with data from EMA signal prompts (i.e., research-initiated survey of parent stress, parent and child mood, child behaviors) collected earlier in the same day for each participant. The event-signal pairs are constructed non-exclusively, meaning that every signal prompt is matched with all the later event prompts within the day, and vice versa. The mean within-pair time (i.e., time between signal prompt and reported eating occasion) for participants in our sample was 4.216 h (SD: 3.044 h); this time was shortest between signal prompts and breakfast (0.086 h) and longest between signal prompts and dinner (5.427 h). Event prompts that did not have a corresponding signal prompt from earlier within the same day were not included in the analysis. Similarly, signal prompts that did not have a corresponding event prompt later on within the same day were dropped. This process yielded one or more within-day signal-event pairs for each participant; participants without any pairs were excluded from the current analysis ($n = 7$) for a total analytical sample of 3,108 pairs of observations on 109 participants. Parents reported on a range of different types of eating occasions [mean eating occasions reported per day per participant = 1.961 (SD = 0.956)]; specifically, 30.3% of parents reported at least one breakfast meal (80 total signal-breakfast pairs), 82.6% reported at least one lunch meal (647 total signal-lunch pairs), 89.0% reported at least one dinner meal (1,172 total signal-dinner pairs), and 89.9% reported at least one snack (1,209 total signal-snack pairs).

To explore the relationship between the observed parent stress and mood, as well as child mood and behavior earlier in the day and the later use of food parenting practices, we fit linear mixed effect regression models for each of the 4 domains (as outcomes) and 7 signal predictors (as predictors of interest; parent stress, parent/child positive and negative mood, child positive and negative behavior). To minimize the model fitting and interpretational challenges of multicollinear explanatory variables (e.g., parent negative mood and child negative behavior), we fit separate regression models for all the combinations of predictors and outcomes, meaning that there are 28 mixed-effect regression models fitted, each with fixed effects as the parent education, income, one of the signal predictors, the time difference between the meal and mood, and random effects including the individual and time of day. Domain score outcomes were log-transformed after adding one to decrease heteroscedasticity and yield interpretation of effects on a percentage change scale; predictors were standardized so that a one-unit difference in the mood/stress predictor was a 1 standard deviation difference. Models were adjusted for highest parent education, household income, and time difference between the signal-event pair (continuous), and included random effect terms for participant and event time (12–6 AM, 6–12 PM, 12–6 PM, 6–12 AM). All models were fitted in R (4.0.2) using package "lme4" with p-values were calculated using package "lmerTest".

Results

Parental momentary factors associated with food parenting practices

Greater parent positive mood earlier in the day was associated with the use of structured eating practices later in the day (details in Table 3). A one standard deviation difference in parent negative mood earlier in the day was associated with a decrease in use of feeding practices from within the structure domain later on that same day (−2.5%, $p = 0.008$), whereas greater parent positive mood earlier in the day was associated with an increase in use of structure later on that same day (+3.7%, $p = 0.003$). Parent mood (negative or positive) earlier in the day was not found to be significantly associated with use of coercive control, indulgent, or autonomy support feeding practices later that same day in this sample (all p-values >0.05).

Greater parent stress earlier in the day was associated with an increase in the use of coercive control (+3.2%, $p < 0.001$), indulgent (+3.0%, $p < 0.001$) and autonomy support (5.6%, $p < 0.001$) feeding practices later on that same day.

Child momentary factors associated with food parenting practices

As detailed in Table 3, child negative behavior earlier in the day was associated with greater use of autonomy support feeding practices. (+2.9%, $p = 0.004$). Greater child positive behavior earlier in the day was associated with a decrease in parent use of indulgent (−1.6%, $p = 0.020$) and autonomy-support (3.2%, $p = 0.002$) feeding practices later that same day. Child behavior (positive or negative) was not found to be significantly associated with use of coercive control or structured feeding practices later that same day (all p-values >0.05).

Child negative mood earlier in the day was associated with an increase in indulgent (+1.3%, $p = 0.025$) and a decrease in the use of structure (−2.5%, $p = 0.001$) feeding practices, whereas child positive mood earlier in the day was associated with an increase in the use of structured feeding practices (+3.5%, $p < 0.001$) later that same day. Child mood (positive or negative) was not found to be significantly associated with use of coercive control or autonomy support feeding practices later that same day within the current sample (all p-values >0.05).

Discussion

The current study sought to understand momentary influences of parental stress, parent and child mood, and child behavior on parent's subsequent use of specific food parenting practices. Specifically, we hypothesized that higher stress, lower mood (parent or child), and worse child behavior earlier on in the day would be associated with increased use of less supportive parent feeding practices later on that same day. To our knowledge, the current study is the first one to examine momentary influences on the use of such a broad range of food parenting practices, including practices from across the four higher-order domains most commonly discussed in current conceptual models of food parenting practices (structure, autonomy support, coercive control, indulgence) (2). This study represents an important next step toward the future development of interventions to promote the use of supportive food parenting practices that are more responsive to free living environments including momentary change in context and circumstances. Overall, findings align with study hypotheses in that parent stress, parent and child low mood, and child negative

TABLE 3 Adjusted temporal associations between parent- (mood, stress) and child- (mood, behavior) factors early in the day and food parenting practices (coercive, indulgent, structure, autonomy support) later that same day ($n = 109$ parent-child pairs; 3,108 eating occasions).

	Coercive		Indulgent		Structure		Autonomy support	
	Regression coefficient	*P*-value	Regression coefficient	*P*-value	Regression coefficient	*P*-value	Regression coefficient	*P*-value
Parent factors								
Positive parent mood	0.010	0.340	0.006	0.505	**0.037**	**0.003**	−0.004	0.807
Negative parent mood	−0.011	0.166	−0.008	0.264	**−0.025**	**0.008**	0.001	0.926
Parent stress	**0.032**	**<0.001**	**0.030**	**<0.001**	0.013	0.202	**0.056**	**<0.001**
Child factors								
Positive child mood	−0.009	0.299	0.006	0.448	**0.035**	**<0.001**	0.006	0.616
Negative child mood	0.00949	0.169	**0.013**	**0.025**	**−0.025**	**0.001**	0.009	0.329
Positive child behavior	−0.008	0.325	**−0.016**	**0.020**	0.008	0.399	**−0.032**	**0.002**
Negative child behavior	0.013	0.081	0.013	0.051	−0.014	0.123	**0.029**	**0.004**

Each number is the regression coefficient estimation of the fixed effect of the corresponding signal covariate with the corresponding domain outcome, adjusting for three fixed effect terms: highest parent education, household income, and time difference between the signal-event pair (continuous); and two random effect terms: participant and time of the day that the event happens (categorically by "12–6 AM", "6–12 PM", "12–6 PM", "6–12 AM").
Bold values indicate a p-value <0.05. Numbers are rounded to even.

behaviors early in the day were found to be associated with the use of less supportive food parenting practices later that same day; important nuances to these findings are discussed in detail below.

In alignment with study hypotheses, higher levels of parent stress early in the day was found to be associated with increased use of coercive control and indulgent feeding practices later that same day. These findings lend quantitative support to the findings stemming from our prior qualitative study in which parents who were interviewed described responding to stressful situations or circumstances by "downshifting" their mealtime interactions with their children away from aspirational efforts (high structure) toward more responsive feeding (coercive control, indulgence); specifically, findings from the current study provide evidence of temporal ordering of the momentary influence of stress on specific parent feeding practices (6). These findings also align, in part, with previous EMA studies by Berge and colleagues which found that parental stress experienced earlier in the day were associated with use of pressure-to-eat parenting practices at the evening meal; interestingly, Berge found no association between stress and food restriction, which is another aspect of coercive control food parenting (16, 17). The fact that the current study conceptualized individual coercive control behaviors (e.g., pressure-to-eat, restriction, threats/bribes) together under a single higher-order domain of coercive control, limits direct comparisons between studies. Findings from the current study also extend the prior work of Berge and colleagues, by examining the potential impact of stress on a wider range of stress on a broader range of parent feeding practices; future research should seek to replicate these findings, including examination of a similarly broad range of parent feeding practices. Further, future research should seek to specifically examine if the shift from more supportive—to less supportive—practices in the face of stressful circumstances, which was previously described by parents within qualitative research, can be observed using quantitative methods (6). Clinicians and public health practitioners may want to consider discussing with parents the impact that stress can have on their interactions with their child at subsequent mealtimes and work with parents to identify opportunities for stress reduction as well as the development of problem solving strategies to successfully navigate stressful situations as they arise.

Contrary to study hypotheses, greater levels of parental stress and negative behavior earlier in the day were all associated with greater parent use of autonomy support feeding practices later that same day. These findings suggest that when faced with greater challenges (i.e., stress, low poor, child negative behaviors) parents responded by increasing their engagement in feeding practices that supported their child's independence at mealtime, including behaviors such as involving their child in choosing what they wanted to eat, teaching them about the benefits and drawbacks of certain foods, and engaging in encouragement or negotiation regarding the types and amounts of foods eaten by their child at meals. The current study does not shed light on why parents chose to increase engagement in autonomy support practices and these findings feel particularly challenging to interpret given that it feels somewhat counterintuitive to see increases in autonomy support and coercive control in response to higher levels of parent-reported stress. That said, it might be that parents in this sample responded to high stress or otherwise challenging situations by moving away from maintaining some of the more covert- or structure-based food parenting practices and toward more overt food parenting practices, including practices from within both the autonomy support and coercive control domains. A parent experiencing high stress or whose child is experiencing low mood or behavior-related challenges might feel less equipped to maintain their usual level of structure a mealtimes, and respond instead by engaging in more direct goal-oriented interactions with their child around food at mealtimes. This direct interaction could look like autonomy support behaviors, coercive control behaviors, or both depending on the individual family circumstances and skills sets. For example, if early morning stress challenged a parent's ability to meal plan, they might lean more on including their child in helping them make these decisions in an effort to complete the task and to be inclusive of the child in a way that could promote more positive interactions at the future meal; alternatively, another parent experiencing a stressful day might respond by engaging in pressure-to-eat with the goal of rushing their child through the meal to "get it over with".

Future studies should aim to replicate the findings that greater levels of parental stress and negative behavior earlier in the day were all associated with greater parent use of autonomy support feeding practices and seek to deepen our understanding of the connection between challenging circumstances and parents increased use of autonomy support practices; this deepened understanding of the mechanisms at play will be key in future intervention development. Public health practitioners should seek to explore ways they can help support families in maintaining structure in the face of challenging circumstances, as well as encourage families to choose autonomy support practices over coercive control practices when possible. It is also important to note that while autonomy support behaviors has been identified as supportive of the development of healthful eating patterns and dietary intake in young children (2), the specific feeding practices that make up this higher-order domain have been studied far less that other specific feeding practices (e.g., pressure-to-eat, restriction, availability, accessibility) (2–5). Further, it is possible that items developed to measure autonomy support within the Real-time Parent Feeding Practices survey tool (14) are indeed measuring a parenting practice that better aligns with a different higher-order domain (e.g., coercive control). For example, parents might interpret what "negotiate" means differently than current theoretical models and researchers intend them to. It is crucial that future research continue to understand which specific aspects of autonomy support associated with healthful dietary intake overtime in young children to allow for the development of interventions tailored to promote food parenting practices most supportive of positive child outcomes overtime.

There are both strengths and limitations to this study. First, this study adds significantly to the emerging literature aimed at broadening our conceptualization of food parenting practices, by being the first, to our knowledge, to examine momentary influences on the use of such a broad range of food parenting practices, including practices from across the four higher-order domains most commonly discussed in current conceptual models of food parenting practices (structure, autonomy support, coercive control, indulgence) (2). Additionally, this study was able to assess the impact of a range of momentary predictors, including both parent (stress and mood) and child (mood and behavior) factors. Further, while the overall sample size of this study was small ($n = 109$), the ability to use data from each single-event reported *via* EMA resulted in a total of 3,108 signal-event-pairs for analysis, which is a strength of this data collection approach. EMA data collection, including measures of parental stress, parent and child mood, child behaviors and food parenting practices are reliant on parent self-report which may introduce some social desirability bias to responses. However, repetitive, real-time reporting of feeding practices represents a move away from gathering parent report of aspirational perceptions and enables us to capture more variation in behaviors by not asking parents to reduce their actual practices down to a single average response (6, 14). It is possible that repetitive data collection and reporting on one's own behavior might act as a mini-intervention, leading parents to change their behavior over the course of the data collection time period.

Conclusion

The current study sought to understand how parent stress, parent and child mood and child eating behaviors early in the day are temporally associated with parent's use of specific food parenting practices later that same day. This study represents an extension of recent research which has highlighted that food parenting practices are not static behaviors, rather they are context specific and responsive to momentary factors within the home and family environment. Findings from the current study support and extend prior research support prior finding indicating that parent and child mood, stress and child behavior earlier in the day are associated with parent's use of specific food parenting practices later in that same day. Currently, clinical and public health recommendations made to parents largely overlook the impact of momentary contextual influences on food parenting practices. By identifying circumstances in which parents are most likely to struggle to use supportive feeding practices, findings from the current study can inform the development of just-in-time adaptive interventions aimed at supporting parents' use of food parenting practices that are supportive of healthful child dietary intake and eating behaviors in a way that is responsive to shifting momentary factors.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by University of Minnesota Twin Cities. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

KL is the principal investigator for the Kids EAT! study, conceptualized the paper, assisted with data interpretation, and worked collaboratively with all co-authors to write the paper. ZJ conducted the data analysis. JW oversaw the data analysis conducted by ZI. JB and JF provided mentorship throughout the conceptualization of the Kids EAT! research study and critically reviewed all drafts of the paper. DN-S provided mentorship throughout the conceptualization of the Kids EAT! research study and is the principal investigator for the EAT 2010–2018 study, the larger study from which the study participants were recruited. All authors assisted with conceptualization of the paper, critically reviewed the full paper, gave final approval this version to be published, and agreed to be accountable for all aspects of the work regarding the accuracy or integrity of any part of the work.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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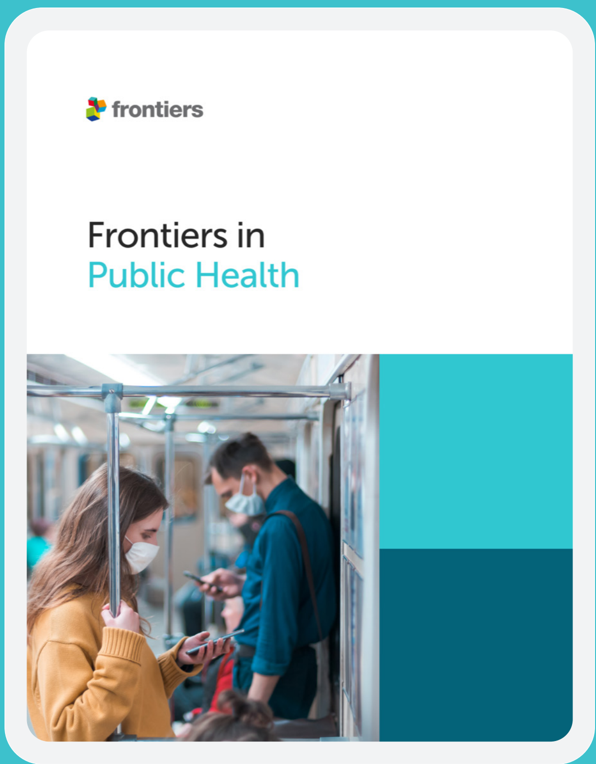

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