

Title: Effect of a responsive parenting intervention on child emotional overeating is mediated by reduced maternal use of food to soothe: The INSIGHT RCT

Authors: Holly A. Harris¹, Stephanie Anzman-Frasca², Michele E. Marini¹, Ian M. Paul³, Leann L. Birch⁴, Jennifer S. Savage¹

Affiliations:

¹Center for Childhood Obesity Research, The Pennsylvania State University, University Park, PA, USA.

²Department of Pediatrics, Jacobs School of Medicine and Biomedical Sciences, University at Buffalo, NY, USA.

³Pediatrics and Public Health Sciences, Penn State College of Medicine, Hershey, PA, USA.

⁴Department of Foods and Nutrition, University of Georgia, Athens, GA, USA.

Keywords:

Child, emotional overeating, food to soothe, obesity prevention, parent feeding practices, responsive parenting

Running title: INSIGHT's effect on emotional overeating

Address for correspondence: Dr Jennifer Savage, Center for Childhood Obesity Research, 129 Noll Laboratory, The Pennsylvania State University, University Park, PA 16802. Phone: 814-865-0514. E-mail: jfs195@psu.edu

Abbreviations:

RP, Responsive parenting; INSIGHT, Intervention Nurses Start Infants Growing on Healthy Trajectories; RCT, Randomized Clinical Trial; BMI, Body Mass Index

1 **Abstract**

2 **Background:** Child emotional overeating is a risk factor for obesity that is learned in the home
3 environment. Parents' use of food to soothe child distress may contribute to the development of
4 children's emotional overeating.

5 **Objectives:** To examine the effect of a responsive parenting (RP) intervention on mother-
6 reported child emotional overeating, and explore whether effects are mediated by mother-
7 reported use of food to soothe child distress.

8 **Methods:** The sample included primiparous mother-infant dyads randomized to a RP
9 intervention ($n=105$) or home safety control group ($n=102$). Nurses delivered RP guidance in
10 four behavioral domains: sleeping, fussy, alert/calm, and drowsy. Mothers reported their use of
11 food to soothe at age 18 months and child emotional overeating at age 30 months. Mediation was
12 analyzed using the SAS PROCESS macro.

13 **Results:** RP intervention mothers reported less frequent use of food to soothe and perceived their
14 child's emotional overeating as lower compared to the control group. Food to soothe mediated
15 the RP intervention effect on child emotional overeating (mediation model: $R^2=0.13$, $P<0.0001$).

16 **Conclusions:** Children's emotional overeating may be modified through an early life RP
17 intervention. Teaching parents alternative techniques to soothe child distress rather than feeding
18 may curb emotional overeating development to reduce future obesity risk.

19

20 **Introduction**

21 Eating in response to negative emotions – ‘emotional overeating’ (1) – develops early in life
22 (2) and is linked to poor diets (3) and higher weight status (4). Emotional overeating may reflect
23 deficits in emotion regulation (5) and disrupted appetite self-regulation (6). Heritability analyses
24 show that children learn to emotionally overeat in the family home environment (7, 8), but
25 evidence related to its etiology is limited. Parents’ use of non-responsive feeding practices may
26 teach young children that the pleasurable properties of eating can attenuate negative emotions
27 which reinforces emotional overeating (9). The current analysis tests this theory empirically
28 within the context of an early obesity prevention trial designed to promote responsive parenting
29 (RP). RP broadly describes parents’ prompt and developmentally appropriate responses to their
30 child’s cues, including hunger and satiety cues (10).

31 Parents’ use of food to soothe their child’s distress (or ‘emotional feeding’) may result in
32 overfeeding and limit opportunities for the child to build self-soothing skills (11). Use of food to
33 soothe is associated with increased weight gain in infancy (12) and childhood (13), and
34 emotional overeating may play a role in this association (14). Infants who exhibit greater
35 temperamental negativity may elicit parents’ use of food to soothe, and negative affect, which is
36 broadly characterized by a child’s tendency to express fear, sadness, anger and discomfort (15),
37 may exacerbate the bidirectional, longitudinal association between parent use of food to soothe
38 and child emotional overeating (16). Parental feeding practices are known modifiable
39 intervention targets (17), therefore teaching parents to use alternative soothing strategies may
40 prevent emotional overeating.

41 **The Intervention Nurses Start Infants Growing on Healthy Trajectories (INSIGHT)**
42 **Randomized Clinical Trial (RCT)** (18) showed that providing RP guidance to first-time mothers

43 prevented rapid infant weight gain (19) and obesity at 3 years (20) compared to a home safety
44 control group. INSIGHT's central hypothesis is that RP anticipatory guidance promotes child
45 self-regulation and shared parent-child responsibility for feeding to reduce children's risk for
46 overeating and overweight (18). One component of the RP curriculum focused on providing
47 mothers with alternative soothing strategies to feeding (18). Mothers who received the RP
48 intervention reported using food to soothe less frequently than the control group (17); however,
49 intervention effects on parental use of food to soothe have not been examined beyond infancy.

50 This analysis aims to examine the effects of the INSIGHT RP intervention on mother-
51 reported child emotional overeating and determine if effects are mediated by mother-reported use
52 of food to soothe child distress. We hypothesize that mothers receiving the RP intervention will
53 report lower child emotional overeating than the control group, and that this effect is mediated by
54 mothers' use of food to soothe. Based on previous data that infant negativity impacts mothers'
55 use of food to soothe (21), an exploratory aim of this study was to examine whether this process
56 varied by infant negative affect.

57 **Methods**

58 *Study design and participants*

59 Details of the INSIGHT RCT study design, recruitment and CONSORT diagram have been
60 published elsewhere (18). This study was approved by the Human Subjects Protection Office of
61 the Penn State College of Medicine's Human Subjects Protection Office and registered at
62 <http://www.clinicaltrials.gov> prior to participant enrollment (Registry number: NCT01167270;
63 registered 21 July 2010). Mothers and their newborns were recruited from one maternity ward in
64 central Pennsylvania between January 2012 and March 2014. Mothers were eligible to
65 participate in the study if they were primiparous, English-speaking and ≥ 20 years of age, and if

66 their newborns were full-term (≥ 37 weeks gestation), singleton and had a birth weight of
67 ≥ 2500 g. Mother-infant dyads were randomized to a RP intervention or a home safety control
68 group using a computer-generated algorithm, stratified by birth weight for gestational age ($< 50^{\text{th}}$
69 percentile or $\geq 50^{\text{th}}$ percentile) and intended feeding mode (breastfeeding or formula). Following
70 randomization at infant age 2 weeks, intervention materials were mailed to all participants (18).
71 Research nurses administered both the RP and control interventions at home visits conducted at
72 child age 3-4, 16, 28, and 40 weeks and at research center visits at 1 and 2 years. Of the 279
73 mother-infant dyads who completed the 3-4 week visit, 243 remained in the study by 2 years.
74 The sample for the current analysis is 207, as 36 participants had missing data on emotional
75 overeating ($n=27$), food to soothe ($n=19$), or negative affect ($n=9$). Mothers included in the
76 current analysis were more likely to be older (29.5 vs. 26.3 years, $P < 0.0001$), married (82% vs.
77 57%, $P < 0.0001$), White (95% vs. 74%, $P < 0.0001$), have a higher income (82% vs. 45% earned
78 $\geq \$50,000$, $P = 0.03$) and have a college/university education (73% vs. 33%, $P < 0.0001$) compared
79 to those who had missing data on the present variables of interest or had dropped out before child
80 age 2 years.

81 ***Responsive Parenting (RP) Intervention***

82 A detailed description of the INSIGHT curriculum has been published (18). Briefly, the
83 nurses delivered the RP intervention content to mothers which centered around anticipatory
84 guidance for managing four infant behavioral states: sleeping, fussy, alert and calm, and drowsy.
85 RP guidance for infant fussing included teaching mothers to identify hunger and distinguish
86 hunger from other sources of infant distress. To provide mothers with alternative strategies to
87 feeding to calm their infants, mothers were provided with an educational video, *The Happiest*
88 *Baby on the Block* (22), in the first weeks following delivery. At the first home visit, the nurses

89 demonstrated these calming strategies to soothe a non-hungry infant (e.g. swaddling, swinging or
90 offering a pacifier). Content related to using alternatives to food to soothe child distress was
91 discussed at each home visit to promote the child's development of self-regulation and capacity
92 to self-soothe. At child age 1 year, mothers were provided with an age-appropriate video, *The*
93 *Happiest Toddler on the Block* (23), to support mothers in managing child tantrums. Mothers in
94 the control group received an intervention of comparable intensity delivered by the same
95 research nurses but focused on home safety (including food safety and choking prevention)
96 within the framework of the four infant behavioral states. The home safety visits were designed
97 as an 'attention control' such that the two study groups received distinct, non-overlapping
98 interventions of equal intensity. Implementation fidelity was routinely assessed throughout the
99 intervention (20). Adherence to message delivery was documented at every home visit by
100 participating mothers indicating the topics addressed during each home visit on an evaluation
101 form. Similarly, research nurses completed a self-report checklist of intervention messages
102 delivered in each visit. Research nurses also audio-recorded the home visits every 6 months, after
103 obtaining verbal consent from the participant to record the session. These recordings were
104 monitored by project staff who provided ongoing coaching and supervision to the research
105 nurses in a report.

106 ***Measures***

107 ***Sociodemographic characteristics.*** Data were collected online and managed using
108 REDCap (24). Paper surveys were mailed to participants without Internet connectivity ($n=20$).
109 Participants provided demographic information at enrollment (e.g., maternal race/ethnicity,
110 marital status, annual household income and highest educational attainment). Maternal age, pre-
111 pregnancy weight and height, and infant gestational age, sex, and birth weight were extracted

112 from medical charts. At child age 28 weeks, mothers reported on their frequency of breast and
113 formula feeding. Predominant breastfeeding was defined if $\geq 80\%$ of milk feedings were
114 breastmilk, either at the breast or bottle. Researchers measured child weight and height/length at
115 1, 2 and 3 year clinic visits. Anthropometric measures were converted to age- and sex-adjusted
116 Body Mass Index (BMI) z-scores based on the World Health Organization growth standards (25)
117 before child age 2 years, and Centers for Disease Control and Prevention growth reference (26)
118 for children 2 years and older.

119 *Mothers' use of food to soothe.* Mothers self-reported their use of food to soothe child
120 distress using 12 items from a modified version of the Baby's Basic Needs Questionnaire (27) at
121 child age 18 months. These items were previously used to evaluate INSIGHT intervention effects
122 at child age 8, 16, 32 and 44 weeks (17). Mothers rated how often they used food to soothe child
123 distress across a variety of situations, regardless if hunger was the source of infant distress, on a
124 5-point Likert scale with responses anchored from never (1) to always (5). This time-point was
125 selected because age 18 months represents a developmental period when toddlers are becoming
126 increasingly autonomous (28), acquiring emotion regulation skills (29), and are likely to be
127 offered table foods that the parents are consuming (30). Items were averaged to create an overall
128 score with higher scores indicating mothers' greater use of food to soothe ($\alpha=0.85$). The food to
129 soothe scale can also be divided into two factors: contextual-based (6 items: $\alpha=0.74$) and
130 emotion-based (6 items: $\alpha=0.88$) food to soothe. Contextual-based food to soothe assesses the
131 frequency of mothers' use of food to quiet, distract or manage a distressed child in a variety of
132 day-to-day situations (e.g. in the car or shopping). Emotion-based food to soothe assesses the
133 frequency of mothers' feeding children in response to child distress or maternal emotions (e.g.
134 stress, frustration or anger).

135 ***Child emotional overeating.*** The Children’s Eating Behaviour Questionnaire (CEBQ) (31),
136 a 35 item validated parent-report measure, was assessed at child age 30 months. The emotional
137 overeating subscale is used in the current analysis to measure mothers’ perceptions of child
138 emotional overeating. Mothers reported if their child ate more when worried, annoyed, anxious
139 or has nothing else to do (4 items). Items were scored from never (1) to always (5) and averaged,
140 with higher scores indicating children’s greater tendency to emotionally overeat ($\alpha=0.72$).

141 ***Temperament.*** The Infant Behavior Questionnaire (IBQ - Revised) – Very Short Form (15)
142 was assessed at infant age 16 weeks. The negative affectivity super-factor is examined in the
143 current study (12 items; $\alpha=0.81$). Mothers also completed three subscales of the Early Childhood
144 Behavior Questionnaire (ECBQ) (32) at age 2 years: frustration (12 items; $\alpha=0.82$), inhibitory
145 control (12 items; $\alpha=0.87$) and soothability (9 items; $\alpha=0.82$). Items in both temperament
146 measures were scored from never (1) to always (7) and averaged within each subscale/super-
147 factor. Higher scores indicated higher levels of that temperament dimension. The earliest
148 measure of infant temperament (age 16 weeks) was used to address the exploratory research aim,
149 while the early childhood measure (age 2 years) is included for descriptive purposes.

150 ***Statistical analysis***

151 Data were analyzed using SAS 9.4 (SAS Institute, Cary, NC). Statistical significance was
152 defined as $P<0.05$, and all inferential tests were 2-sided. Sociodemographics and the main
153 variables of interest were compared by study group using independent samples t-tests and χ^2 tests
154 for continuous and categorical variables, respectively.

155 Mediation analysis was used to examine if mothers’ use of food to soothe explained study
156 group effects on child emotional overeating. Mediation analysis was planned if the following
157 criteria were met: the mediator (food to soothe) was significantly associated with both the

158 independent variable (study group; **Figure 1**, *a* pathway) and the outcome variable (emotional
159 overeating), controlling for the independent variable (study group; **Figure 1**, *b* pathway) in
160 separate multivariate linear regressions, adjusting for covariates. We planned to include
161 participant sociodemographic characteristics in the model as covariates if they were significantly
162 associated with maternal use of food to soothe and child emotional overeating. The SAS
163 PROCESS macro (33) was used to analyze whether food to soothe mediated the association
164 between study group and child emotional overeating (model 4). Bias-corrected bootstrapping
165 Confidence Intervals (CI) at the 95% level were used for 10 000 resamples to establish direct (*c*’)
166 and indirect (*ab*) effects. Mediation was established if the indirect effect’s CI did not include ‘0’
167 (33). In the case of significant overall effects, dimensions of food to soothe (i.e., contextual- and
168 emotion-based food to soothe) will be probed further.

169 A conditional process analysis was used to examine whether early infant negative affect
170 altered the study group effect on maternal food to soothe, which, in turn, may influence
171 intervention effects on child emotional overeating. This corresponds to moderation of the ‘*a*’
172 pathway in **Figure 1** or ‘*action theory*’ (34). Infant negative affect was entered into the
173 conditional process model in the SAS PROCESS macro (33). Moderated mediation was
174 established if the index of moderated mediation’s bias-corrected bootstrapping CI did not include
175 ‘0’ (33).

176 Multiple imputation (Markov chain Monte Carlo) was used to account for missing values
177 and confirm the results in the full sample of participants who remained active in the study at age
178 2 years ($n=243$). Information on maternal pre-pregnancy BMI, marital status, age at recruitment,
179 education, study group and use of food to soothe (18 months); and child sex, gestational age,
180 birth weight, negative affect (16 weeks) and emotional overeating (30 months) were used to

181 estimate imputations. Analyses examining study group effects on the main variables of interest
182 and the mediation analyses were based on pooled results of 9 imputed data sets. Similar results
183 were found using the imputed data sets (except where indicated), and therefore results are
184 reported for the complete cases ($n=207$).

185 **Results**

186 Participant characteristics are shown in **Table 1**. Mothers were primiparous,
187 predominantly white, non-Hispanic, married, and college educated with the majority of mothers
188 reporting annual household incomes $\geq \$50,000$. Maternal and child sociodemographic
189 characteristics, and child frustration, inhibitory control and soothability, did not differ by study
190 group.

191 Pearson correlations showed no association between child BMI z-scores at ages 1, 2 and 3
192 years and child emotional overeating ($P_s > 0.11$). In the analytic sample ($n=207$), child frustration
193 ($r=0.31$, $P < 0.0001$), inhibitory control ($r=-0.26$, $P=0.0002$) and soothability ($r=-0.26$,
194 $P=0.0002$) at 2 years was associated with child emotional overeating at 30 months. Infant
195 negative affect at 16 weeks was not associated with mothers' use of food to soothe at 18 months
196 ($r=0.12$, $P=0.08$), but was positively associated with child emotional overeating at 30 months
197 ($r=0.26$, $P < 0.001$). Mothers' use of food to soothe at 18 months was positively associated with
198 child emotional overeating at 30 months ($r=0.36$, $P < 0.0001$).

199 Compared to the control group ($n=102$), mothers who received the RP intervention
200 ($n=105$) reported using less food to soothe at child age 18 months [M (SE)= 1.81 (0.06) vs. 1.58
201 (0.05), $P=0.002$, $d=0.44$] and perceived their child to be lower in emotional overeating at age 30
202 months [1.47 (0.05) vs. 1.35 (0.04), $P=0.046$, $d=0.27$]. Compared to the control group, mothers
203 who received the RP intervention also perceived their infant to have lower negative affect at age

204 16 weeks [3.53 (0.09) vs. 3.26 (0.09), $P=0.04$, $d=0.30$]. However, the effect of study group on
205 infant negative affect did not reach significance in the imputed dataset [3.47 (0.08) vs. 3.26
206 (0.08), $P=0.053$, $d=0.25$], reflecting trend-level data previously reported in the full INSIGHT
207 sample (35).

208 *Mediation analyses*

209 Mothers' use of food to soothe met the criteria for mediation and was examined as a
210 mediator of study group effects on child emotional overeating. No sociodemographic covariates
211 were associated with both mothers' use of food to soothe and child emotional overeating. The
212 unstandardized path coefficients and standard errors for the mediation model of study group on
213 child emotional overeating through maternal use of food to soothe are shown in **Table 2**. There
214 was a significant indirect effect (ab) of study group on child emotional overeating through
215 maternal use of food to soothe [B(SE)= -0.06 (0.03), 95% CI: -0.12 to -0.02]. The mediation
216 model explained 13% of the variance in mothers' perceptions of child emotional overeating at
217 age 30 months. Mediation models for contextual- and emotional-based food to soothe yielded
218 similar results (data not shown).

219 Next, we tested whether the indirect effect of study group on child emotional overeating
220 through mothers' use of food to soothe varied by infant negative affect using moderated
221 mediation. The index of moderated mediation indicated that the indirect effect was not
222 moderated by infant negative affect [B (SE)=0.02 (0.02), 95% CI: -0.03 to 0.07]. In other words,
223 the intervention effect on child emotional overeating through mothers' use of food to soothe
224 occurred independent of child temperament. The indirect effect of study group on child
225 emotional overeating through mothers' use of food to soothe also occurred independent of child
226 sex (data not shown). We reran the mediation and moderated mediation analyses, replacing

227 mothers' use of food to soothe measured at 18 months with earlier measures (infant age 8, 16, 32
228 and 44 weeks). Results were similar, with the exception of mothers' use of food to soothe at
229 infant age 8 weeks, where the indirect effect was not significant (data not shown).

230 **Discussion**

231 We extend the knowledge of emotional overeating etiology within the context of a
232 randomized obesity prevention intervention focused on responsive parenting (RP). Mothers who
233 received a RP intervention that began during the early postpartum period reported using less food
234 to soothe child distress at child age 18 months compared to a home safety control group,
235 indicating maintenance in study group differences from infancy (17) to toddlerhood. Further,
236 mediation analyses supported the hypothesis that mothers' use of food to soothe child distress
237 could be one mechanism driving the development of emotional overeating. Mothers' less
238 frequent use of food to soothe appears to explain the RP intervention effect on decreased child
239 emotional overeating at 30 months, regardless of negative affect during infancy. However,
240 emotional overeating at 30 months was not associated with child weight up to age 3 years.

241 Aparicio et al.(5) propose that emotional overeating, as a function of maladaptive emotion
242 regulation, may be one pathway that links stress to child obesity. Results from the current study
243 show that indicators of child self-regulation (i.e., lower inhibitory control, capacity to self-
244 soothe, and tolerance for frustration) were inversely associated with child emotional overeating.
245 This is consistent with findings in older children. Emotional and behavioral problems in 3 year
246 old Dutch children predicted increasing trajectories of emotional overeating from the ages of 4 to
247 10 years (36). In the same cohort, Derks et al.(4) showed that emotional overeating was both a
248 predictor and consequence of higher weight status from 4 to 10 years, yet these factors were not
249 cross-sectionally associated at 4 years. Associations between emotional overeating and weight

250 may be age-dependent, emerging with children's increasing autonomy and access to foods (4) or
251 adiposity rebound (14). This may explain our non-significant association between emotional
252 overeating and weight status in younger children. Future research should examine these
253 associations prospectively in the INSIGHT study, or in trials with school-aged children or
254 adolescents to further understand whether and how the modification of emotional overeating can
255 impact weight status.

256 Current findings provide further support for emotional overeating as a learned and
257 therefore modifiable behavior, corroborating findings from heritability analyses (2, 7, 8) and
258 another obesity prevention intervention (37). Two British twin cohort studies show that 71-93%
259 of variability in emotional overeating is explained by the 'shared home environment' (2, 7). As
260 architects of their child's home environment, parents are therefore appropriate targets for
261 intervention. The NOURISH RCT (37) reported that mothers who received a responsive feeding
262 intervention perceived their 2 year old child to be lower in emotional overeating than the
263 'standard care' control group at 6 months post-intervention. Like the current study, small effects
264 on emotional overeating were reported ($d=0.24$) (37). However, the intervention effect on
265 emotional overeating in NOURISH did not persist to child age 5 years ($P=0.09$) (38). While both
266 shared a similar focus on responsive feeding practices, INSIGHT took on a broader approach to
267 RP across infant behavioral states and was implemented earlier in infancy compared to
268 NOURISH (3-4 weeks old vs. 4-7 months old). Examining whether the INSIGHT RP
269 intervention effects on child emotional overeating are sustained later in child development will
270 further the understanding of *how* and *when* to ideally modify emotional eating trajectories.

271 The INSIGHT intervention effects on mothers' self-reported use of food to soothe child
272 distress previously reported (17) persisted into toddlerhood. Toddlerhood is a particularly

273 sensitive period in which children acquire skills to regulate their own emotions through
274 interactions with the social environment (29). Concurrently, this period may also represent a time
275 in which children's ability to compensate for variations in energy density (i.e., appetite self-
276 regulation) may diminish (39). Parents are therefore critical in scaffolding children's appropriate
277 responses to both emotions and appetite. While feeding may temporarily suppress children's
278 distress by activating the reward system (40), feeding for reasons unrelated to hunger may
279 undermine children's appetite self-regulation or encourage them to adopt maladaptive emotion
280 regulation strategies. In an experimental study, children of parents who reported using food as a
281 tool to control their behavior during the preschool years (3-5 years old) ate more in the absence
282 of hunger under a stress-induced condition 2 years later (41). Our current study shows that
283 anticipatory RP guidance decreases mothers' use of food to soothe child distress, which in turn,
284 may reduce children's tendency to eat in response to stressors.

285 Individual children differ in their clarity of expressing cues, making RP guidance (and
286 therefore, avoiding feeding to soothe) easier or more difficult to follow depending on child
287 characteristics (42). For example, mothers of children who exhibit greater negative affect may
288 respond to aversive emotions by feeding to quickly soothe an upset child (27). However,
289 differential susceptibility theory (43) posits that children with certain behavioral predispositions
290 (i.e., negativity) may be more sensitive to changes in their environment, suggesting that those
291 intervention-group children with high levels of negativity might benefit the most from an
292 intervention like INSIGHT (44). However, when focusing on the present outcomes of interest,
293 findings suggest that an RP intervention can reduce child emotional overeating through mothers'
294 decreased use of food to soothe child distress, regardless of early infant negative affect. Similar
295 to our prior findings of main effects on child self-regulation (44), these results suggest that the

296 RP intervention's effects on feeding to soothe and child emotional overeating are robust across
297 levels of infant negative affect. While these findings are encouraging in terms of the
298 generalizability of the RP intervention's effects in these areas, it is important to note that we
299 were unable to assess negativity earlier than age 16 weeks. At 16 weeks, there is some evidence
300 to suggest that the experience of being in the RP intervention group was already starting to affect
301 mothers' perceptions of their child's negativity (35). Although not statistically significant,
302 mothers in the RP intervention reported their child to be lower in negativity compared to the
303 control group (3.3 vs. 3.5, $P < 0.10$). Ideally, moderated mediation performed in the current
304 analysis would have used an earlier, "purer" measure of negative affect, however this was not
305 possible.

306 Other limitations of the present study include the use of mother reports of both maternal
307 feeding to soothe and child emotional overeating. While mother-reported measures allow
308 representation of behaviors over a period of time, they may be subject to social desirability bias,
309 including higher reporting of behaviors encouraged by the RP intervention in the RP group.
310 Common methods of parent-report may also have resulted in inflated associations (i.e., shared
311 method variance). Further, given the complex nature of parent-child interactions, there may be
312 additional mediators involved in the etiology of child emotional overeating which are not
313 explored in the current study. For example, future research could examine the role of maternal
314 eating behaviors, including mothers' own emotional overeating, on the development of child
315 emotional overeating. Both interventions were delivered by the same research nurses to eliminate
316 any potential biases introduced by nurse characteristics. While contamination between the RP
317 intervention and the home safety control group is a possibility, the research nurses followed a
318 strict curriculum with routine fidelity assessment to prevent intervention drift. The observed

319 effects on primary and secondary outcomes (17, 19, 20) and fidelity results (20) suggest that this
320 possibility did not preclude the implementation of an effective RP intervention. Lastly, the
321 sample was relatively homogenous, consisting of predominantly white, middle-income, well-
322 educated and English-speaking primiparous mothers, limiting the generalizability of findings.

323 There were several strengths to the current analysis. The mediation analysis undertaken is
324 novel and responds directly to recent calls for understanding pathways involved in nutrition-
325 related outcomes (45). The analysis reveals not only mechanisms underlying child health
326 outcomes, but *how* to intervene in these processes. The mediation model examined was grounded
327 within a strong theoretical framework (5) and also informed by empirical observational findings
328 in older children (16). We found consistent indirect effects of study group on child emotional
329 overeating through mothers' use of food to soothe at infant age 16, 32 and 44 weeks, affirming
330 the mechanism examined during toddlerhood. Current findings provide further support for the
331 efficacy of the INSIGHT RP intervention (17, 19, 20).

332 Our results suggest that the development of child emotional overeating can be modified in
333 the context of an early-life obesity prevention intervention. Parents appear to play an important
334 role in the etiological pathway of emotional overeating through how they respond to children's
335 distress. Using food to soothe child distress may teach children that negative emotions can be
336 suppressed through the pleasant effects of eating, thus reinforcing emotional overeating. Guiding
337 parents to use alternative methods to soothe their child's distress rather than feeding could
338 ultimately reduce the expression of emotional overeating in early childhood. This causal
339 evidence supporting RP as a predictor of these outcomes can inform future study designs aiming
340 to prevent emotional overeating and attendant effects on poor diet and obesity.

341

342 **Acknowledgements**

343 This research was supported by the National Institute of Diabetes and Digestive and Kidney
344 Diseases (R01DK088244); National Institutes of Health/National Center for Advancing
345 Translational Sciences (UL1TR000127); the Children’s Miracle Network at Penn State
346 Children’s Hospital; US Department of Agriculture (2011-67001-30117), which supported
347 graduate students; and the Pennsylvania State University Clinical and Translational Science
348 Award from the Penn State Clinical and Translational Research Institute, which supported
349 research electronic data capture.

350 The authors acknowledge Jessica Beiler, MPH, Jennifer Stokes, RN, Patricia Carper, RN,
351 Heather Stokes, Susan Rzucidlo, MSN, RN, Lindsey Hess, MS, and Eric Loken, PhD, for their
352 assistance with this project. The content is solely the responsibility of the authors and does not
353 necessarily represent the official views of the NIH.

354 HAH, JSS, LLB, and IMP designed the research; HAH and MEM conducted the statistical
355 analyses; HAH, JSS and SAF wrote the paper; all authors contributed to the interpretation of the
356 results and manuscript preparation, and read and approved the final manuscript.

357

358 **COI Statement**

359 The authors have no financial relationships relevant to the article to disclose.

360

References

1. Macht M. How emotions affect eating: A five-way model. *Appetite* 2008;50:1-11.
2. Herle M, Fildes A, Rijdsdijk F, Steinsbekk S, Llewellyn C. The home environment shapes emotional eating. *Child Dev* 2018;89:1423-34.
3. Jalo E, Konttinen H, Vepsäläinen H, et al. Emotional Eating, Health Behaviours, and Obesity in Children: A 12-Country Cross-Sectional Study. *Nutrients* 2019;11:351.
4. Derks IP, Sijbrands EJ, Wake M, et al. Eating behavior and body composition across childhood: A prospective cohort study. *Int J Behav Nutr Phys Act* 2018;15:96.
5. Aparicio E, Canals J, Arija V, De Henauw S, Michels N. The role of emotion regulation in childhood obesity: Implications for prevention and treatment. *Nutr Res Rev* 2016;29:17-29.
6. Freitas A, Albuquerque G, Silva C, Oliveira A. Appetite-related eating behaviours: An overview of assessment methods, determinants and effects on children's weight. *Ann Nutr Metab* 2018;73:19-29.
7. Herle M, Fildes A, Llewellyn CH. Emotional eating is learned not inherited in children, regardless of obesity risk. *Pediatr Obes* 2018;13:628-31.
8. Herle M, Fildes A, Steinsbekk S, Rijdsdijk F, Llewellyn CH. Emotional over- and under-eating in early childhood are learned not inherited. *Sci Rep* 2017;7:9092.
9. Kaplan HI, Kaplan HS. The psychosomatic concept of obesity. *J Nerv Ment Dis* 1957;125: 181-201.
10. van den Boom DC. The influence of temperament and mothering on attachment and exploration: An experimental manipulation of sensitive responsiveness among lower-class mothers with irritable infants. *Child Dev* 1994;65:1457-77.
11. Anzman-Frasca S, Liu S, Gates KM, Paul IM, Rovine MJ, Birch LL. Infants' transitions out of a fussing/crying state are modifiable and are related to weight status. *Infancy* 2013;18:662-86.
12. Stifter CA, Moding KJ. Understanding and measuring parent use of food to soothe infant and toddler distress: A longitudinal study from 6 to 18 months of age. *Appetite* 2015;95:188-96.
13. Chong SY, Chittleborough CR, Gregory T, Lynch JW, Mittinty MN, Smithers LG. Associations of parental food-choice control and use of food to soothe with adiposity in childhood and adolescence. *Appetite* 2017;113:71-77.
14. Jansen PW, Derks IPM, Batenburg A, et al. Using food to soothe in infancy is prospectively associated with childhood BMI in a population-based cohort. *J Nutr* 2019;149:788-94.

15. Putnam SP, Helbig AL, Gartstein MA, Rothbart MK, Leerkes E. Development and assessment of Short and Very Short Forms of the Infant Behavior Questionnaire-Revised. *J Pers Assess* 2014;96:445-58.
16. Steinsbekk S, Barker ED, Llewellyn C, Fildes A, Wichstrom L. Emotional feeding and emotional eating: Reciprocal processes and the influence of negative affectivity. *Child Dev* 2018;89:1234-46.
17. Savage JS, Hohman EE, Marini ME, Shelly A, Paul IM, Birch LL. INSIGHT responsive parenting intervention and infant feeding practices: Randomized clinical trial. *Int J Behav Nutr Phys Act* 2018;15:64.
18. Paul IM, Williams JS, Anzman-Frasca S, et al. The Intervention Nurses Start Infants Growing on Healthy Trajectories (INSIGHT) study. *BMC Pediatr* 2014;14:184.
19. Savage JS, Birch LL, Marini M, Anzman-Frasca S, Paul IM. Effect of the INSIGHT responsive parenting intervention on rapid infant weight gain and overweight status at age 1 year: A randomized clinical. *JAMA Pediatr* 2016;170:742-49.
20. Paul IM, Savage JS, Anzman-Frasca S, et al. Effect of a responsive parenting educational intervention on childhood weight outcomes at 3 years of age: The INSIGHT randomized clinical trial. *JAMA* 2018;320:461-68.
21. Stifter CA, Moding KJ. Infant temperament and parent use of food to soothe predict change in weight-for-length across infancy: Early risk factors for childhood obesity. *Int J Obes* 2018;42:1631-38.
22. Karp H, Montee N. *The Happiest Baby on the Block: The New Way to Calm Crying and Help Your Baby Sleep Longer*. 2006, 128 minutes.
23. Karp H, Montee N. *The Happiest Toddler on the Block*. 2004, 69 minutes.
24. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)-- A metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform* 2009;42:377-81.
25. World Health Organization. *WHO Child Growth Standards: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age: Methods and development*. Geneva, Switzerland: World Health Organization, 2006.
26. Kuczumski RJ, Ogden CL, Grummer-Strawn LM, et al. CDC growth charts: United States. *Adv Data* 2000;314:1-27.
27. Stifter CA, Anzman-Frasca S, Birch LL, Voegtline K. Parent use of food to soothe infant/toddler distress and child weight status. An exploratory study. *Appetite* 2011;57:693-9.
28. Brownell CA, Kopp CB. *Socioemotional development in the toddler years: Transitions and transformations*. Guilford Press, 2010.
29. Zeman J, Cassano M, Perry-Parrish C, Stegall S. Emotion regulation in children and adolescents. *J Dev Behav Pediatr* 2006;27: 155-168.

30. Birch LL, Doub AE. Learning to eat: birth to age 2 y. *Am J Clin Nutr* 2014;99: 723S-728S.
31. Wardle J, Guthrie CA, Sanderson S, Rapoport L. Development of the Children's Eating Behaviour Questionnaire. *J Child Psych Psychiatry* 2001;42:963-70.
32. Putnam SP, Gartstein MA, Rothbart MK. Measurement of fine-grained aspects of toddler temperament: The Early Childhood Behavior Questionnaire. *Infant Behav Dev* 2006;29:386-401.
33. Hayes AF. Introduction to mediation, moderation, and conditional process analysis: A regression-based approach. 2nd. ed. New York: Guilford Publications Inc. 2018.
34. Fairchild AJ, MacKinnon DP. A general model for testing mediation and moderation effects. *Prev Sci* 2009;10:87-99.
35. Anzman-Frasca S, Paul IM, Moding KJ, Savage JS, Hohman EE, Birch LL. Effects of the INSIGHT obesity preventive intervention on reported and observed infant temperament. *J Dev Behav Pediatr* 2018;39:736-743.
36. Derks IPM, Bolhuis K, Sijbrands EJG, Gaillard R, Hillegers MHJ, Jansen PW. Predictors and patterns of eating behaviors across childhood: Results from The Generation R study. *Appetite* 2019;141:104295.
37. Daniels LA, Mallan KM, Battistutta D, et al. Child eating behavior outcomes of an early feeding intervention to reduce risk indicators for child obesity: The NOURISH RCT. *Obesity (Silver Spring)* 2014;22:E104-E111.
38. Magarey A, Mauch C, Mallan K, et al. Child dietary and eating behavior outcomes up to 3.5 years after an early feeding intervention: The NOURISH RCT. *Obesity (Silver Spring)* 2016;24:1537-45.
39. Brugaillères P, Issanchou S, Nicklaus S, Chabanet C, Schwartz C. Caloric compensation in infants: developmental changes around the age of 1 year and associations with anthropometric measurements up to 2 years. *Am J Clin Nutr* 2019;109:1344-52.
40. Erlanson-Albertsson C. How palatable food disrupts appetite regulation. *Basic Clin Pharmacol Toxicol* 2005;97:61-73.
41. Farrow CV, Haycraft E, Blissett JM. Teaching our children when to eat: how parental feeding practices inform the development of emotional eating—a longitudinal experimental design. *Am J Clin Nutr* 2015;101:908-913.
42. Buvinger E, Rosenblum K, Miller AL, Kaciroti NA, Lumeng JC. Observed infant food cue responsivity: Associations with maternal report of infant eating behavior, breastfeeding, and infant weight gain. *Appetite* 2017;112:219-26.
43. Belsky J, Bakermans-Kranenburg MJ, Van IJzendoorn MH. For better and for worse: Differential susceptibility to environmental influences. *Curr Dir Psychol Sci* 2007;16:300-4.

44. Anzman-Frasca S, Stifter CA, Paul IM, Birch LL. Negative temperament as a moderator of intervention effects in infancy: Testing a differential susceptibility model. *Prev Sci* 2014;15: 643-53.
45. McDaniel HL, Fairchild AJ. Best (but oft-forgotten) practices: Mediation analysis. *Am J Clin Nutr* 2017;105:1259-71.

Table 1: INSIGHT child and maternal sociodemographic characteristics by study group

	RP intervention (<i>n</i> = 105)	Control (<i>n</i> = 102)	<i>P</i> -value
Child			
Male sex, N (%)	54 (51)	51 (50)	0.84
Gestational age (wk), mean (SD)	39.5 (1.3)	39.5 (1.2)	0.82
Birth weight (kg), mean (SD)	3.42 (0.45)	3.46 (0.42)	0.52
Predominantly breastfed at 6 mo, N (%)	39 (37.1)	36 (17.4)	0.78
Temperament at 24 mo, mean (SD)			
Frustration	3.1 (0.7)	3.3 (0.8)	0.08
Inhibition	4.4 (0.8)	4.5 (0.8)	0.89
Soothability	5.5 (0.7)	5.4 (0.6)	0.27
Mother			
Age (y) at recruitment, mean (SD)	29.4 (4.2)	29.6 (4.8)	0.77
Pre-pregnancy BMI, mean (SD)	25.6 (5.0)	25.6 (5.2)	0.97
White, N (%)	98 (93.3)	98 (96.1)	0.38
Hispanic, N (%)	6 (2.9)	5 (2.4)	0.78
Married, N (%)	85 (81)	84 (82)	0.79
Annual household income, N (%)			
≤\$24,999	7 (6.7)	7 (6.9)	
\$25,000-\$49,999	2 (1.9)	15 (14.7)	
\$50,000-\$99,999	67 (63.8)	38 (37.3)	
\$100,000 or more	27 (25.7)	38 (37.3)	
Do not know or refuse to answer	2 (1.9)	4 (3.9)	
Education, N (%)			
High school graduate or less	7 (6.7)	8 (7.8)	0.84
Some college	23 (21.9)	19 (18.6)	
College graduate	43 (41.0)	47 (46.1)	
Graduate degree +	32 (30.5)	28 (27.5)	

BMI: Body Mass Index; kg: kilograms; RP: Responsive Parenting; SD: Standard Deviation.

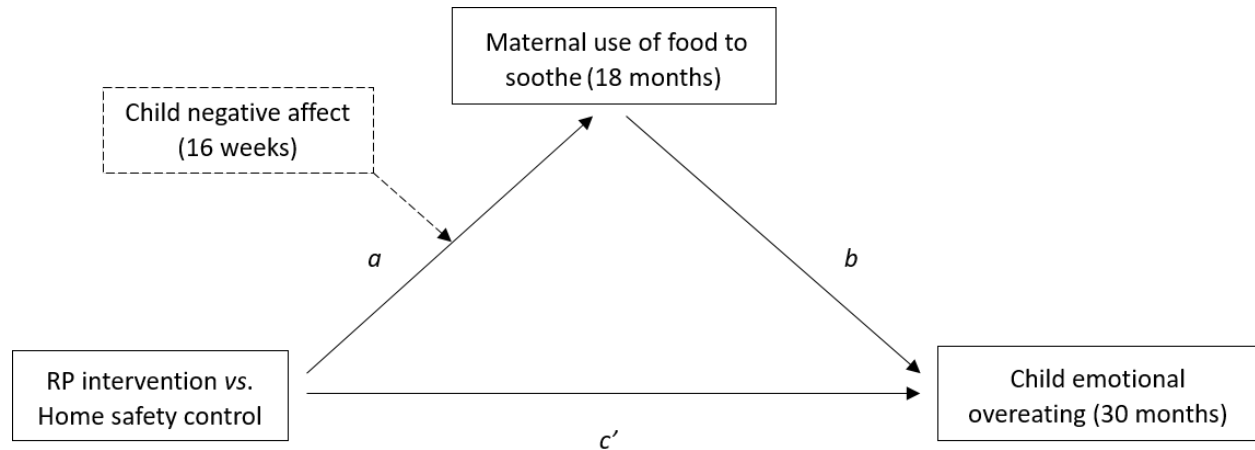
Child temperament measured using the Early Childhood Behavior Questionnaire (32).

Table 2: Estimated path coefficients for the mediation model of the INSIGHT RP intervention on child emotional overeating through mothers' use of food to soothe ($n=207$)

Antecedent		Consequent						
		Maternal food to soothe (<i>'a'</i> pathway)			Child emotional overeating (<i>'b'</i> pathway)			
		B	SE	<i>P</i> -value		B	SE	<i>P</i> -value
Study group (Home safety control vs. RP intervention)	<i>a</i>	-0.22	0.07	0.002	<i>c'</i>	-0.06	0.06	0.32
Maternal food to soothe		-	-	-	<i>b</i>	0.29	0.06	<0.0001
Constant	<i>i</i>	1.81	0.05	<0.001	<i>i</i> ₂	0.95	0.11	<0.0001
$R^2 = 0.04$ F (1, 205)= 9.52, $P=0.002$				$R^2 = 0.13$ F (2, 204) = 15.71, $P<0.0001$				

RP: Responsive Parenting; maternal food to soothe at child age 18 months assessed via the Baby's Basic Needs Questionnaire (27), child emotional overeating at age 30 months via the Children's Eating Behaviour Questionnaire (31). Study group is dummy coded such that safety control = 0; and RP intervention = 1.

Figure 1: Model specification for mediation of the INSIGHT RP intervention on child emotional overeating through maternal food to soothe, moderated by infant negative affect



RP: Responsive Parenting. Maternal use of food to soothe from the Baby's Basic Needs Questionnaire (27); Child emotional overeating from the Children's Eating Behaviour Questionnaire (31); Negative affect from the Infant Behavior Questionnaire (Revised) – Very Short Form (15). Solid lines denote the pathways for the main mediation analysis; the dotted lines indicate the exploratory, moderated mediation analysis