Strategies to promote responsive bottle-feeding in WIC predict less frequent use of food to soothe and healthier weight status for infants with negative temperaments

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Summary

Background: Infants with greater temperamental negative affectivity are at higher risk for overfeeding and excess weight gain.

Objective: To examine whether strategies to promote responsive bottle-feeding within WIC promoted healthier maternal feeding practices and infant weight status among infants with greater negative affectivity.

Methods: Secondary analysis of data from a matched-pair cluster randomized trial. Policy, systems and environmental change (PSE) strategies to promote responsive bottle-feeding were implemented at three WIC clinics; these clinics were compared with three matched control clinics. Linear mixed models tested whether infant negative affectivity interacted with PSE strategies to predict feeding and weight outcomes when infants were 4–6 months old.

Results: Significant interactions between infant negative affectivity and PSE strategies were noted. Among infants with high negative affectivity, mothers in PSE clinics reported less frequent use of food to soothe ($p = 0.009$) compared with mothers in control clinics. Among infants with moderate ($p = 0.008$) or high ($p = 0.029$) negative affectivity, infants in PSE clinics had healthier weight status compared with infants in control clinics.

Conclusions: Promotion of responsive bottle-feeding is an effective way to support WIC mothers and reduce risk for overfeeding and excess weight gain, particularly for mothers of infants with greater negative affectivity.

KEYWORDS
food to soothe, infant temperament, responsive feeding, Special Supplemental Program for Women, Infants, and Children (WIC), weight-for-age z-score

1 | INTRODUCTION

Dimensions of infant temperament, defined as individual differences in emotional expression, activity levels and attention/regulation,[1] are associated with infants' subsequent risk for excess weight gain and later obesity.[2–6] Negative affectivity is among the most studied dimensions of temperament as it relates to obesity risk and represents the infant's propensity towards exhibiting higher levels of crying, fearfulness, and anger, and lower levels of soothability and stimulation threshold.[1] Collectively, previous research illustrates infants who exhibit greater levels of negative affectivity gain weight at faster rates during infancy and have higher weight status during early childhood than infants who exhibit lower levels of negative affectivity.[2–6]

Infant feeding practices are the most likely mechanisms underlying associations between negative affectivity and weight outcomes because caregivers often use feeding to modify infant behaviour.[5–8]

Ideally, caregivers will engage in responsive feeding, defined as feeding infants in ways that are responsive to infant hunger and satiation cues and that are developmentally appropriate.[9,10] Responsive feeding is associated with healthier weight gain trajectories during infancy and early childhood,[9–15] as well as more consistent feeding routines and lower reliance on non-responsive feeding practices, such as pressuring infants to eat or using food to soothe a fussy infant.[15–17] In reality, a significant proportion of mothers to young infants believe crying is always an indication of hunger[12,18] and feeding is a frequent response to reduce fussing and crying, in part because feeding is effective for reducing distress.[19] Fussing and crying are late-stage feeding cues, but are also attributable to many other non-hunger needs (e.g., reduced stimulation, sleep).[12] Thus, although use of food to soothe a fussy infant is form of responsiveness to infant cues, it may result in a failure to discriminate between infant satiety cues and other cues, resulting in a mismatch between the infant's needs and the caregiver's responses and an increased risk for overfeeding. Indeed, greater use of food to soothe during infancy is associated with greater weight gain and higher weight status during later infancy and early childhood.[5,20]

Consideration of associations between infant negative affectivity, feeding patterns and risk for excess weight gain is particularly relevant to efforts to support low-income and Hispanic families who experience disproportionate risk for obesity and related comorbidities.[21] In particular, a large proportion of low-income, Hispanic mothers report they attribute crying to hunger, adhere to pressuring feeding styles and employ bottle-feeding practices associated with overfeeding, such as feeding higher than recommended amounts of formula or adding sugar or baby food to their infants' bottles.[22–24] In addition, low-income, Hispanic mothers who perceive their infants cry too much or desire to increase the duration of their infants' sleeping bouts also report switching from breastfeeding to formula-feeding because they believe it will better satisfy their infant, leading to less crying and longer sleeping bouts.[25,26] Familial and cultural preferences for calm and chubby infants likely underline mothers' use of food to align infant behaviour to familial and cultural expectations.[27] Taken together, these findings suggest mothers' interpretation of and response to infant cues is an important target for interventions aimed at modifying risk for overfeeding during bottle-feeding and excess weight gain, especially among mothers of infants who exhibit higher levels of negative affectivity[28] and within low-income and Hispanic populations.[23]

The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) is an effective way to reach and support families with young infants. WIC is a federally-funded food and nutrition education programme that serves over 6 million U.S. families annually.[29] WIC serves low-income pregnant, breastfeeding, and postpartum women and their infants and children under 5 years of age by providing healthy foods, nutrition education, breastfeeding support, and referrals to healthcare and other community services. Within many WIC programmes, WIC staff implement a well-developed curriculum to teach pregnant women and new mothers about infant development, developmentally appropriate expectations for infant behaviours (e.g., feeding and sleeping patterns), non-food soothing strategies, and responsive feeding.[30] Because a large proportion of WIC infants are partially or exclusively bottle-fed,[31] placing them at higher risk for overfeeding and rapid weight gain,[32,33] we recently developed and tested the effects of policy, systems, and environmental change (PSE) strategies to augment this curriculum by tailoring and contextualizing these messages for bottle-feeding interactions.[34] We found that infants within WIC clinics wherein PSE strategies were implemented were less likely to exhibit rapid weight gain during early infancy compared with infants in control clinics.[34] However, we did not find associations between implementation of PSE strategies and mothers' feeding practices or styles or infant feeding patterns, making the mechanisms underlying associations between PSE strategies and reduced risk for rapid weight gain unclear.

Previous research illustrates consideration of interactions between intervention effects and infant temperament allows for a deeper understanding of how and for whom the intervention works because effects may not be detected when interactions with infant temperament are not considered.[35,36] This understanding can enhance clinical translation of research findings by informing efforts to target specific intervention strategies to each family's unique needs. For example, Anzman-Frasca and colleagues reported infant negativity moderated effects of a responsive parenting intervention on mothers' parenting satisfaction and infants' weight gain between birth and 3 years.[35] For infants with higher levels of negative affectivity, participation in the intervention was associated with greater parenting satisfaction for mothers and a trend towards slower weight gain for infants; similar intervention benefits were not seen for infants with lower levels of negative affectivity. These findings align with the differential susceptibility model, which posits certain children (e.g., those with higher levels of negative affectivity) are more susceptible to negative impacts of non-responsive parenting but also positive impacts of responsive parenting.[36] Thus, intervention benefits may be particularly evident for infants with greater susceptibility, which would primarily be identified through analysis of whether and how markers of susceptibility (e.g., high infant negative affectivity) interact with intervention effects to predict outcomes of interest. To this end, the aim of this secondary analysis was to consider infant temperament within the context of our previous study[34] by examining whether infant negative affectivity moderated effects of PSE strategies on mothers' feeding practices and infant weight status during early infancy.

2 | METHODS

2.1 | Participants

This study was a secondary analysis of data from a matched-pair cluster randomized trial that examined effects of PSE strategies to promote responsive bottle-feeding within WIC.[34] A detailed description of study methods can be found elsewhere[34] but will be described briefly here. Mothers with infants born between April and August

2019 were recruited from six WIC clinics in Los Angeles County. A priori power analyses indicated a sample size of 100/group would be sufficient to detect significant differences in mothers' feeding practices and infants' weight-for-age percentiles at power of 0.80 and alpha = 0.05.[37] We recruited ~40 participants per clinic to meet our sample size goal and allow for attrition, resulting in a final sample of 246 mother–infant dyads.

Mothers were recruited in-person by trained WIC staff during their newborn enrolment appointment. Inclusion criteria were: (1) mothers 18 years or older with a newborn at the time of recruitment and (2) singleton infants born full-term. Exclusion criteria were infants: (1) born preterm (less than 37 weeks gestation), (2) who were not the biological child of the mother (e.g., the mother was fostering the child), and (3) who experienced growth faltering. To verify inclusion and exclusion criteria, all mothers completed a brief screening questionnaire at enrolment that determined maternal age, weeks gestation at birth and biological relationship to the infant; all infants were weighed to check for growth faltering. This study was reviewed and approved by the California State Committee for Protection of Human Subjects (https://oshpd.ca.gov/data-and-reports/data-resources/cphs/; protocol #: 2019-044-Public Health Foundation Enterprise [PHFE] WIC) and the California Polytechnic State University Institutional Review Board. All participants provided written and oral informed consent for participation.

2.2 | PSE strategies

PSE strategies were implemented at three of the WIC clinics (PSE clinics); the other three WIC clinics served as usual care controls (Control clinics). A detailed description of the PSE strategies, their rationale and development can be found elsewhere.[34] In brief, PSE strategies focused on: (1) more inclusive assessment of early infant feeding decisions and direct connection of this assessment to tailored intervention tools and (2) enhancement of WIC resources to support responsive bottle-feeding. With respect to the first set of PSE strategies, we revised the assessments WIC staff used to determine mothers' breast- and/or bottle-feeding patterns and practices to improve WIC staff's abilities to identify problematic feeding patterns and practices (e.g., feeding too much or too frequently, always responding to crying with feeding) and subsequently provide tailored counselling and resources to the mother to address any issues. With respect to the second set of PSE strategies, we expanded existing WIC tools (e.g., one-on-one education, interactive texting) to include evidence-based messaging related to responsive bottle-feeding. All materials are available by request to the corresponding author.

2.3 | Study protocol

Mothers completed study questionnaires when infants were newborn, and then again when their infants were 3 and 6 months of age. The newborn questionnaire was completed in-person at WIC clinics. Mothers then completed subsequent questionnaires via Qualtrics (an online survey platform: https://qualtrics.com) when their infants were 3 and 6 months of age. Retention rates through 6 months were high: 90.6% ($n = 223/N = 246$) of mothers participated at 3 months and 93.1% ($n = 229/N = 246$) of mothers participated at 6 months.

2.4 | Measures

All questionnaires were available in English and Spanish. The following measures were included:

2.4.1 | Infant temperament

Mothers completed the Infant Behaviour Questionnaire – Revised Very Short Form (IBQ-RVS) when their infants were 6 months old.[38] The IBQ-RVS is a 37-item instrument that measures three dimensions of infant temperament: surgency/extraversion, negative affectivity, and orientation/regulation capacity. The present study focused on the negative affectivity sub-scale, which is characterized by sadness, distress to limitations, and fear. Items were scored on a Likert scale of 1 (Never) to 7 (Always), with higher scores representing greater infant negative affectivity. The negative affectivity sub-scale has demonstrated validity and good internal consistency ($\alpha = 0.78$) in diverse populations of mothers of infants younger than 3 months and up to 3 years old.[38]

2.4.2 | Use of food to soothe

At all assessments, mothers completed the Infant Feeding Styles Questionnaire (IFSQ).[9]

Although the IFSQ assesses six feeding style constructs and 13 sub-constructs,[9] the current analysis focused on the pressuring–soothing sub-construct of the pressuring feeding style construct. The pressuring–soothing sub-construct items assess the extent to which mothers use food to soothe infant distress (example item: "When my baby cries, I immediately feed him/her."). Items were scored on a Likert scale of 1 (Never) to 5 (Always), with higher scores representing greater use of food to soothe. The pressuring–soothing sub-construct has demonstrated validity and good internal consistency ($\alpha = 0.79$–0.85) in diverse samples of low-income and Hispanic mothers with young infants.[9,39]

2.4.3 | Daily feeding frequency

At all assessments, mothers reported whether they were exclusively breastfeeding, exclusively formula-feeding, or combination feeding. Mothers also estimated the percentage of daily milk feedings that came from bottles versus directly from the breast (response range = 0%–100%). At 3 and 6 months, mothers reported how many feedings their infant received daily.

2.4.4 | Addition of cereal to the bottle

At 3 and 6 months, mothers who reported any bottle-feeding also reported the frequency to which they added cereal to their infants' bottles via an item adapted from the Infant Feeding Practices Study II[40]: "How often have you added baby cereal to your infant's bottle of formula or pumped (expressed) breast milk in the past 2 weeks?" Response options ranged from 1 (Never) to 6 (Every feeding).

2.4.5 | Infant weight-for-age percentile score

Mothers reported infant birth weight; previous research illustrates mother-reported birth weight correlates strongly with measured weight from medical records.[41] Subsequent infant weights were measured by trained WIC staff and using a portable digital infant scale that was calibrated regularly (Seca 334; Seca Deutschland). WIC staff ensured infants were only wearing clean diapers during the weight assessment. Infant weight was initially measured during the newborn assessment, and then during any subsequent follow-up appointments. These appointments occurred on different timelines and with differing frequencies for each infant, dependent on families' needs. Measured weights were extracted from WIC electronic records for this study. The World Health Organization (WHO) Anthro software version 3.0.1 (www.who.int/childgrowth/en/) was used to calculate age- and sex-specific percentiles based on the WHO growth standards. The majority of infants included in the present study had data on birth weight ($n = 220/N = 246$; 89.4%). At least one other weight measurement between 4 and 6 months of age was available for 157 infants (63.8%). To account for the possibility that change in weight-for-age percentiles differed based on the age of the infant at the time of the last weight assessment, infant age at last weight measure was included as a covariate in models predicting weight-for-age percentiles between 4 and 6 months of age.

2.4.6 | Demographics

Family demographics were assessed at baseline. Mothers reported their age, education level, parity, family income level, employment status, and race and ethnicity.

2.5 | Statistical analysis

All analyses were conducted using SAS v.9.4 (SAS Institute Inc., North Carolina). Data were thoroughly cleaned and tested for normality prior to analysis. Of the 246 participants who enrolled in this study, 124 were in PSE clinics and 122 were in control clinics. Missing data for variables of interest were minimal: 17 participants did not complete the 6-month assessment, 8 did not complete the IBQ-RVS, and 4 were missing daily feeding frequency data. With respect to the question assessing the frequency to which they added cereal to the bottle, 28 did not respond to this question because they did not use bottles (thus the question was not relevant to them) and 8 left this question blank. The convenience sub-sample of infants with weight measures and weight-for-age percentiles at 4–6 months included 157 dyads. Accordingly, the sample size for models with infant negative affectivity or pressuring–soothing as the response variable was $n = 221$, for models with daily feeding frequency as the response variable was $n = 217$, for models with frequency of adding cereal to the bottle as the response variable was $n = 190$, and for models with infant weight-for-age percentiles at 4–6 months was $n = 157$.

Hierarchical models were used for all inferential analyses to account for the correlated nature of clustering of participants within clinics; clinic was treated as a random effect in all models.[42] Because infant negative affectivity was only measured at 6 months, models examined concurrent associations between PSE strategies, infant negative affectivity at 6 months, feeding practices at 6 months, and weight status at 4–6 months. In models examining whether infant negative affectivity moderated associations between PSE strategies and mothers' reported feeding practices or infant weight-for-age percentiles, infant negative affectivity was mean-centred and moderation was tested by including main and interactive effects of temperament and intervention group. Post hoc tests of simple slopes were conducted to test the significance of associations between infant negative affectivity and mothers' feeding practices and infant weight-for-age percentiles for PSE versus control clinics. To further aid in interpretation of interactions, post hoc tests were conducted to determine and visualize mean differences in mothers' feeding practices and infant weight-for-age percentiles by PSE versus control clinics and infants with low (1 SD below the mean) versus moderate (mean) versus high (1 SD above the mean) levels of negative affectivity.[43]

All models were adjusted for infant sex, mother education level and parity, and family income level. Infant birth weight-for-age percentile score and age at last weight measure was included as a covariate in models predicting weight-for-age percentiles between 4 and 6 months of age. Preliminary analyses revealed that a subset of mothers reported no bottle-feeding when their infants were 6 months of age (i.e., percentage of daily milk feedings that came from bottles versus the breast = 0; $n = 23$). Given the PSE strategies focused on promoting responsive bottle-feeding, we also conducted sensitivity analyses wherein all models were rerun excluding mothers who reported no bottle-feeding. Statistical significance was defined as $p < 0.05$ and statistical trends were noted when $p < 0.10$.

3 | RESULTS

3.1 | Sample characteristics at newborn enrolment

Average infant age at newborn enrolment was 11.5 (SD = 8.9, range = 0–52) days and average mother age was 28.9 (SD = 6.3, range = 18–48) years. Average infant weight-for-age percentile score at birth was 46.6 (SD = 28.6, range = 0.6–99.5). Forty percent of mothers reported their education level was a high school diploma or less, 38% were primiparous, 24% reported their annual family income

TABLE 1 Linear mixed models predicting pressuring–soothing (use of food to soothe), feeding frequency, and frequency of adding cereal to the bottle at 6 months: Interactions between PSE strategies[a] and infant negative affectivity

	Model 1 Pressuring–soothing ($n = 221$)			Model 2 Feeding frequency ($n = 217$)			Model 3 Adding cereal to bottle ($n = 186$)		
	Estimate	SE	*p*-value	Estimate	SE	*p*-value	Estimate	SE	*p*-value
PSE strategies	0.01	0.17	0.97	−0.51	0.51	0.324	−0.15	0.19	0.436
Infant negative affectivity[b]	0.27	0.09	0.003	1.22	0.30	<0.001	0.18	0.11	0.098
PSE strategies × infant negative affectivity[b] interaction	−0.30	0.12	0.017	−0.92	0.43	0.032	−0.33	0.15	0.030

Note: All models adjusted for infant sex, mother education level and parity, and family income level.
[a]Policy, systems and environmental strategies to promote responsive bottle-feeding for participants in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC).
[b]Infant negative affectivity was mean-centred in all linear mixed models.

was less than $10 000 per year, and 77% were Hispanic. Slightly over half of mothers (52%, $n = 115$) reported they exclusively breastfed their infant at birth, but only 32% were still exclusively breastfeeding by the newborn enrolment. On average, 50% (SD = 40.7, range = 0%–100%) of infants' daily feedings were from bottles (as opposed to directly from the breast) at the newborn enrolment. This increased to 76% (SD = 38.1, range = 0%–100%) at 6 months.

There were no significant differences for demographic characteristics of participants in PSE clinics versus control clinics, with the exception of ethnicity. Significantly more participants in the PSE clinics (84%) identified as Hispanic compared with control clinics (70%, $p = 0.031$). Of note, average percent of daily feedings from bottles at the newborn enrolment did not differ between PSE ($M = 54.5\%$, SD = 4.6%) and control ($M = 46.2\%$, SD = 4.5%) clinics ($p = 0.193$). Average percent of daily feedings from bottles at 6 months was also similar for PSE ($M = 78.3\%$, SD = 4.6%) and control ($M = 73.9\%$, SD = 4.5%) clinics ($p = 0.504$). In addition, average weight-for-age percentiles at birth did not significantly differ for infants in PSE ($M = 45.6$, SD = 3.2) versus control ($M = 47.7$, SD = 3.1) clinics ($p = 0.641$).

3.2 | Infant negative affectivity for PSE versus control clinics

Average infant negative affectivity score for PSE clinics was 3.3 (SD = 1.2, range = 0–6.8) and for control clinics was 3.6 (SD = 1.2, range = 0–6.2). Infant negative affectivity did not significantly differ between PSE and control clinics ($F[1,205] = 2.39$, $p = 0.123$). This finding did not change in sensitivity analysis wherein mothers who reported no bottle-feeding were excluded ($F[1,177] = 0.49$, $p = 0.487$).

3.3 | Infant negative affectivity moderated associations between PSE strategies and feeding practices

Infant negative affectivity moderated the association between PSE strategies and the pressuring–soothing sub-construct of the IFSQ (which represents mothers' use of food to soothe) at 6 months ($F[1,203] = 5.83$, $p = 0.017$; Table 1, Model 1). For mothers in control clinics, there was a significant, positive association between infant negative affectivity and use of food to soothe (estimate = 0.27, $p = 0.003$), indicating the greater the infants' negative affectivity, the more frequently the mother used food to soothe. In contrast, infant negative affectivity was not associated with use of food to soothe for mothers in the PSE clinics (estimate = −0.03, $p = 0.701$). Figure 1 further illustrates the moderation effect of infant negative affectivity on

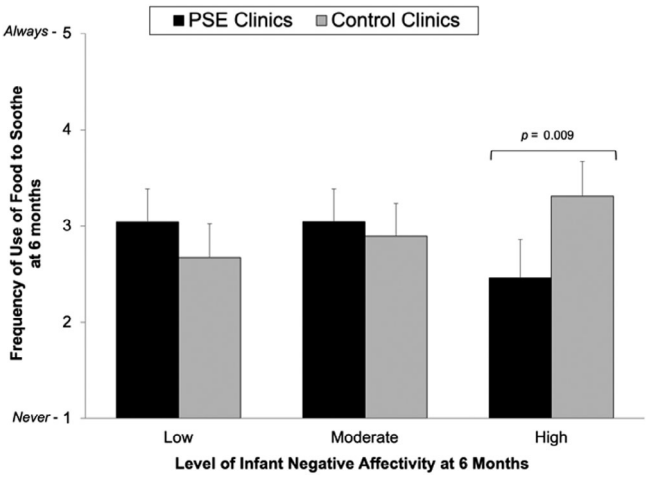

FIGURE 1 Infant negative affectivity at 6 months moderated effects of policy, systems and environmental (PSE) strategies to promote responsive bottle-feeding on mothers' use of food to soothe among participants in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC). To illustrate interactive effects, use of food to soothe was estimated by PSE versus control clinics and for mothers of infants with average levels of negative affectivity (moderate negative affectivity), as well as levels of negative affectivity that were 1 SD below the mean (low negative affectivity) versus 1 SD above the mean (high negative affectivity). Possible score range for pressuring–soothing sub-construct of the Infant Feeding Styles Questionnaire (which represents the frequency to which the mother used food to soothe her infant) was 1 (never) to 5 (always). Linear mixed model was adjusted for infant sex, mother education level and parity, and family income level

effects of PSE strategies on frequency of use of food to soothe; for illustrative purposes, frequency of use of food to soothe was estimated by PSE versus control clinics and for mothers of infants with mean levels of negative affectivity (moderate negative affectivity), as well as levels of negative affectivity that were 1 SD below the mean (low negative affectivity) versus 1 SD above the mean (high negative affectivity). Among infants with high negative affectivity, mothers in the PSE clinics reported significantly less frequent use of food to soothe ($M = 2.5$, SE $= 0.4$) compared with mothers in the control clinics ($M = 3.3$, SE $= 0.4$, $p = 0.009$). No notable changes in significance were seen within sensitivity analyses wherein mothers who reported no bottle-feeding were excluded.

Infant negative affectivity modified the association between PSE strategies and daily feeding frequency at 6 months ($F[1,199] = 4.64$, $p = 0.032$; Table 1, Model 2). For mothers in the control clinics, there was a significant, positive association between infant negative affectivity and number of feedings per day (estimate $= 1.22$, $p < 0.0001$). In contrast, for mothers in the PSE clinics, infant negative affectivity was not associated with number of feedings per day (estimate $= 0.31$, $p = 0.316$). Figure 2 presents daily feeding frequency by PSE versus control clinics and for infants with low (1 SD below the mean) versus moderate (mean) versus high (1 SD above the mean) levels of negative affectivity. Among infants with high negative affectivity, mothers in the PSE clinics trended towards reporting fewer feedings per day ($M = 8.7$, SE $= 1.3$) compared with mothers in the control clinics ($M = 10.6$, SE $= 1.2$; $p = 0.072$). No notable changes in significance were seen within sensitivity analyses wherein mothers who reported no bottle-feeding were excluded.

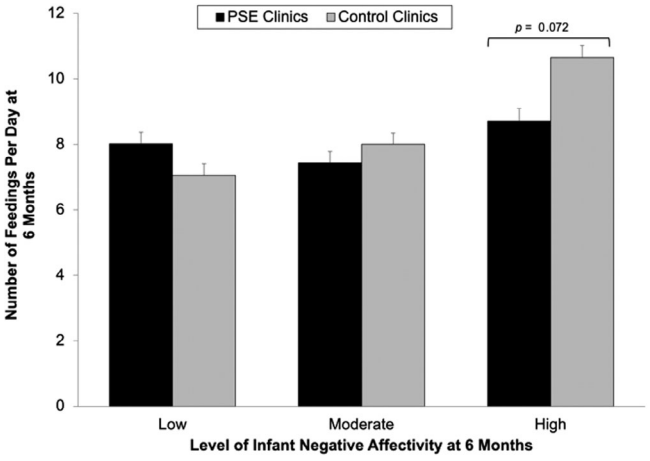

FIGURE 2 Infant negative affectivity at 6 months moderated effects of policy, systems and environmental (PSE) strategies to promote responsive bottle-feeding on daily feeding frequency among participants in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC). To illustrate interactive effects, daily feeding frequency was estimated by PSE versus control clinics and for mothers of infants with average levels of negative affectivity (moderate negative affectivity), as well as levels of negative affectivity that were 1 SD below the mean (low negative affectivity) versus 1 SD above the mean (high negative affectivity). Linear mixed model was adjusted for infant sex, mother education level and parity, and family income level

Infant negative affectivity also modified the association between PSE strategies and the frequency to which mothers added cereal to their infants' bottles at 6 months ($F[1,172] = 4.64$, $p = 0.030$; Table 1, Model 3). For mothers in the control clinics, there was a marginal positive association between infant negative affectivity and frequency of adding cereal to the bottle (estimate $= 0.18$, $p = 0.098$). In contrast, for mothers in the PSE clinics, infant negative affectivity was not associated with frequency of adding cereal to the bottle (estimate $= -0.15$, $p = 0.165$). Figure 3 presents frequency of adding cereal to the bottle by PSE versus control clinics and for mothers of infants with low (1 SD below the mean) versus moderate (mean) versus high (1 SD above the mean) levels of negative affectivity. Among infants with high negative affectivity, mothers in the PSE clinics trended towards reporting less frequent addition of cereal to the bottle ($M = 1.7$, SE $= 0.5$) compared with mothers in the control clinics ($M = 2.4$, SE $= 0.4$; $p = 0.074$). Sensitivity analyses wherein mothers who reported no bottle-feeding were excluded were not relevant because only bottle-feeding mothers were asked to report the frequency to which they added cereal to their infants' bottles.

3.4 | Infant negative affectivity modified associations between PSE strategies and infant weight status at 4–6 months

Within a linear mixed model predicting infant weight-for-age percentiles at 4–6 months, adjusted for infant birth weight-for-age

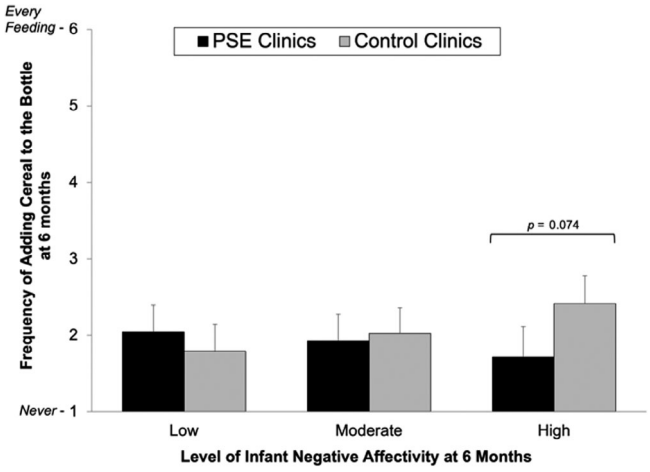

FIGURE 3 Infant negative affectivity at 6 months moderated effects of policy, systems and environmental (PSE) strategies to promote responsive bottle-feeding on frequency of adding cereal to the bottle among participants in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC). To illustrate interactive effects, frequency of adding cereal to the bottle was estimated by PSE versus control clinics and for mothers of infants with average levels of negative affectivity (moderate negative affectivity), as well as levels of negative affectivity that were 1 SD below the mean (low negative affectivity) versus 1 SD above the mean (high negative affectivity). Possible score range for frequency of adding cereal to the bottle was 1 (Never) to 6 (Every feeding). Linear mixed model was adjusted for infant sex, mother education level and parity, and family income level

TABLE 2 Linear mixed models predicting infant weight-for-age percentile scores at 4–6 months: interactions between PSE strategies[a] and infant negative affectivity

	Model 1: All Infants ($n = 157$)[b]			Model 2: Only infants who received bottles ($n = 134$)[c]		
	Estimate	SE	*p*-value	Estimate	SE	*p*-value
PSE strategies	−7.86	5.69	0.169	−9.98	4.98	0.048
Infant negative affectivity[d]	3.22	2.52	0.203	6.01	2.83	0.036
PSE strategies × infant negative affectivity[d] interaction	−6.98	3.42	0.043	−11.28	3.70	0.003

Note: All models adjusted for infant birth weight-for-age percentile score, age at weight assessment and sex; mother education level and parity; and family income level.

[a]Policy, Systems and Environmental strategies to promote responsive bottle-feeding for participants in the Special Supplemental Program for Women, Infants, and Children (WIC).

[b]Includes a convenience sub-sample of infants with a weight measure between 4 and 6 months ($n = 157$).

[c]Sensitivity analyses wherein mothers who reported no bottle-feeding infants at 6 months were excluded ($n = 134$).

[d]Infant negative affectivity was mean-centred in all linear mixed models.

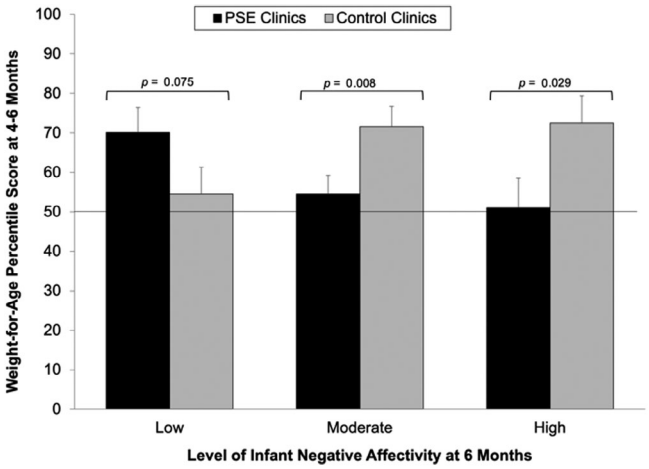

FIGURE 4 Infant negative affectivity at 6 months moderated effects of policy, systems and environmental (PSE) strategies to promote responsive bottle-feeding on infant weight-for-age percentile among participants in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC). To illustrate interactive effects, infant weight-for-age percentile was estimated by PSE versus control clinics and for mothers of infants with average levels of negative affectivity (moderate negative affectivity), as well as levels of negative affectivity that were 1 SD below the mean (low negative affectivity) versus 1 SD above the mean (high negative affectivity). Linear mixed model was adjusted for infant birth weight-for-age percentile score, age at weight assessment and sex, mother education level and parity, and family income level

percentiles, the infant negative affectivity by intervention interaction was significant ($p = 0.043$; Table 2, Model 1). The significance of the interaction strengthened within sensitivity analysis wherein mothers who reported no bottle-feeding were excluded ($p = 0.003$; Table 2, Model 2). For infants in control clinics, there was a positive association between infant negative affectivity and weight-for-age percentile at 4–6 months (estimate = 6.01, $p = 0.036$). For dyads in the PSE clinics, there was a significant negative association between infant negative affectivity and weight-for-age percentile at 4–6 months (estimate = −5.27, $p = 0.037$).

Figure 4 presents weight-for-age percentiles at 4–6 months for infants in the sensitivity sub-sample by PSE versus control clinics and by low (1 SD below the mean) versus moderate (mean) versus high (1 SD above the mean) levels of negative affectivity. For infants with moderate levels of infant negative affectivity, weight-for-age percentile was significantly higher in the control clinics ($M = 71.6$, SE = 5.1) compared with PSE clinics ($M = 54.6$, SE = 4.7; $p = 0.008$). Similarly, for infants with high levels of negative affectivity, weight-for-age percentile was significantly higher in the control clinics ($M = 72.5$, SE = 6.9) compared with PSE clinics ($M = 51.0$, SE = 7.5, $p = 0.029$).

4 | DISCUSSION

Findings from the present study suggest promotion of responsive bottle-feeding within WIC may be an effective way to support mothers of infants with greater negative affectivity to reduce risk for overfeeding and excess weight gain. Within control clinics, expected associations between infant negative affectivity, less desirable feeding practices and higher weight status were seen: greater negative affectivity was associated with more frequent use of food to soothe and greater daily feeding frequency, a trend towards more frequent addition of cereal to the bottle, and higher infant weight-for-age percentile. In contrast, within PSE clinics, infant negative affectivity was not associated with use of food to soothe, feeding frequency, addition of cereal to the bottle, or higher infant weight status. Taken together, these findings enhance our previous work, which demonstrated an association between PSE strategies and healthier rates of infant weight gain that could not be explained by mothers' feeding practices.[34] By exploring whether infant negativity modified associations between PSE strategies, mothers' feeding practices, and infant weight, the present study better elucidated how and for whom the PSE strategies worked. Study findings suggest mothers of infants with greater levels of negative affectivity benefited more from PSE strategies to promote responsive bottle-feeding than mothers of infants with lower levels of negative affectivity.

The PSE strategies developed for this study aimed to expand WIC's ability to provide early, targeted intervention to promote new

mothers' understanding of infant cues and use of responsive feeding practices.[34] These strategies were designed to augment existing resources, including a robust curriculum that teaches pregnant women and new mothers about normal infant behaviour, discrimination of feeding from non-feeding cues, responsive feeding, and effective non-feeding soothing strategies.[30] Specifically, the PSE strategies aimed to help mothers apply existing WIC educational messages and responsive feeding advice to bottle-feeding interactions because bottle-feeding affords mothers with greater opportunities for controlling feeding practices that may lead to overfeeding.[44–46] The present study supports potential translation of this intervention to clinical settings because study findings can inform efforts to target specific intervention strategies to each family's unique needs. For example, a common difficulty observed by WIC staff is mothers' reports of fussy or irritable infants who cannot be soothed. Thus, the findings of the present study may bolster WIC staff's confidence that PSE strategies to promote responsive bottle feedings are likely to help those who need it most: mothers who report challenges interpreting the behavioural cues of their fussy infants.

Infants with greater negative affectivity present unique challenges for new mothers due to their greater levels of fussing and crying and lower levels of stimulation threshold and soothability. Thus, mothers of infants with greater negative affectivity may need additional support to understand their infants' cues and meet their infants' unique temperamental needs, especially as they relate to feeding and soothing.[47] This was evident for participants in control clinics, wherein a significant association between greater infant negative affectivity and more frequent use of food to soothe was noted. These findings are consistent with previous research illustrating greater infant negative affectivity predicts more frequent use of food to soothe,[5,6,48] greater feeding frequency,[49,50] and earlier introduction to complementary foods and beverages, most often via addition of cereal to the bottle,[51,52] likely because feeding effectively reduces fussing and crying.[19]

The contrasting lack of associations between negative affectivity and these feeding practices within PSE clinics suggests PSE strategies to promote responsive bottle-feeding may be an effective way to reduce use of food to soothe, frequent feedings, and addition of cereal to the bottle among WIC mothers whose infants have greater levels of negative affectivity. Of note, differences between PSE and control clinics for feeding practices of mothers of infants with higher levels of negative affectivity were statistically significant, but also clinically relevant. On average, mothers in the PSE clinics reported "seldom" use of food to soothe compared with use of food to soothe "about half the time" for mothers in the control clinics. Mothers in PSE clinics also reported an average of two fewer feedings per day compared with mothers in control clinics, which roughly equates to ~240 kcal difference in daily caloric intake (assuming infants were receiving 6-ounce bottles of formula, which contains 20 kcal/ounce). These differences in feeding practices and patterns likely underlined clinically relevant differences in weight-for-age percentiles seen for infants with higher levels of negativity in the PSE versus control clinics: within the PSE clinics, infants with higher levels of negativity maintained what would be considered a healthy weight status (~50th percentile), whereas higher levels of negative affectivity were associated with significantly elevated weight status (~70th percentile) in control clinics.

Findings related to infant weight status align with proposed models of how infant temperament interacts with environmental conditions to shape infant outcomes. Both the biological sensitivity to context hypothesis[53] and differential susceptibility hypothesis[36] posit that certain individuals (e.g., infants who exhibit greater levels of negative affectivity) are more susceptible to negative effects of negative environmental exposures (e.g., non-responsive parenting), but also more "susceptible" to positive effects of positive exposures (e.g., responsive parenting). Thus, infants with greater levels of negative reactivity are at heightened risk for negative outcomes when there is not a goodness-of-fit between the individual's unique temperamental needs and their caregivers' responses, but also experience greater benefits from early intervention compared with infants with lower levels of negative reactivity.[36] Consistent with these models, associations between greater levels of negative affectivity and greater weight status for infants in control clinics may have been due to poor fit between infants' temperamental needs and mothers' feeding practices and soothing strategies. In addition, greater levels of negative affectivity were associated with a stronger response to the PSE strategies (i.e., lower weight status at 4–6 months), suggesting that infants with greater negative affectivity benefited more from the intervention than infants with lower negative affectivity.

It is notable that, when predicting infant weight status at 4–6 months, the intervention by negative affectivity interaction strengthened when participants who did no bottle-feeding were excluded. Use of food to soothe is more common for breastfeeding than bottle-feeding mothers,[54,55] but may have different implications for the breastfed compared with bottle-fed infant. Specifically, the breastfeeding infant engages in a mix of non-nutritive and nutritive sucking during feeding, whereas the bottle-feeding infant engages almost exclusively in nutritive sucking.[56] Thus, it is plausible for a breastfeeding infant to be soothed without subsequent calorie intake, whereas excess calorie intake during use of food to soothe would be likely for the bottle-feeding infant. However, few studies have examined whether feeding mode moderates associations between infant negative affectivity, feeding practices and infant weight outcomes. In one of the only studies to examine interactions between use of food to soothe and feeding mode during early infancy, Hupp and colleagues reported that neither use of food to soothe nor the interaction between use of food to soothe and feeding mode (breast vs. bottle-feeding) predicted infant weight status during early infancy, which is inconsistent with the findings of the present study and with other studies examining associations between use of food to soothe and infant weight outcomes during later infancy.[54] Given the paucity of studies examining these associations, additional research is needed to understand whether associations between infant negative affectivity, use of food to soothe, and infant weight outcomes differ for breastfed versus bottle-fed infants.

Associations between infant temperament and mothers' feeding practices highlight the bidirectional nature of mother–infant interactions and support the notion that dimensions of temperament may predispose the infant to exhibit behaviours that evoke certain responses from the mother, which can, consequently, shape the mother's feeding and parenting practices, the infant's future behaviours and outcomes, and the mother–infant relationship.[57] However, a limitation of the present study is that concurrent associations between infant temperament, mothers' feeding practices and infant weight status were examined, which limits abilities to understand causal, bidirectional effects. In our previous study, we noted that the feeding practices and styles of mothers within PSE and control clinics did not differ at baseline, suggesting our findings are not due to pre-existing differences between mothers in PSE versus control clinics.[34] In addition, infant levels of negative affectivity did not differ between PSE and control clinics, suggesting the PSE strategies did not affect infant temperament. However, although temperament is generally considered to be stable during early infancy,[58] it is not immutable and markers of negative affectivity (e.g., crying) can be reduced by responsive parenting interventions.[59] In addition, temperament and feeding practices were measured via maternal reports, which could have been biased by experiences within or beyond WIC given previous research illustrates responsive parenting interventions can influence parents' perceptions of infant temperament.[59] It is also possible that mothers' reports were biased by other unmeasured factors that would also affect feeding practices and infant weight status, such as experiences of postpartum depression.[48] Additional limitations include lack of weight data for a significant portion of the sample. Although the high prevalence of Hispanic mothers in this sample was a strength, this study was limited by the under-representation of other racial and ethnic groups, limiting abilities to generalize findings to more racially and ethnically diverse populations. Overall, the present study provides promising support for beneficial effects of PSE strategies to promote responsive bottle-feeding within WIC, but further research that includes longitudinal measures of infant temperament and mothers' feeding practices and styles is warranted to understand study findings more fully.

5 | CONCLUSIONS

Infants who exhibit greater levels of negative affectivity, and whose caregivers subsequently use food to manage their behaviour, are at higher risk for overfeeding and greater rates of weight gain during infancy. These associations are of particular concern for efforts to support low-income and Hispanic mothers, who are at disproportionately higher risk for using non-responsive feeding practices, leading to overfeeding and rapid infant weight gain. In the present study, PSE strategies implemented within WIC to promote responsive bottle-feeding were associated with less frequent use food to soothe and healthier infant weight status for mothers whose infants had greater levels of negative affectivity. Thus, continued efforts to help WIC mothers effectively discriminate hunger and fullness cues from other non-feeding cues and respond to the challenges that can emerge with infants that express higher levels of negative affectivity may be especially effective strategies to support healthy outcomes for WIC families.

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CONFLICT OF INTERESTS

The authors have no financial relationships or conflicts of interest relevant to this article to disclose.

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