Pacifier Use and Early Life Weight Outcomes in the Intervention Nurses Start Infants Growing on Healthy Trajectories Study

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Abstract

Background: Although widely used by infants, little is known about the long-term effects of pacifiers. We investigated relationships between pacifier use in infancy and appetite, temperament, feeding, and weight outcomes through age 2 years using data from the Intervention Nurses Start Infants Growing on Healthy Trajectories study.

Methods: Mother–newborn dyads were randomized to a responsive parenting intervention for obesity prevention or a control group. Infants with data on pacifier use ($n=250$) were categorized as using a pacifier beyond early infancy (≥ 4 months of age) or not. Anthropometrics were measured at 6 months, 1, and 2 years with overweight defined as weight-for-length ≥ 95 th percentile at 1 year and BMI ≥ 85 th percentile at 2 years. Mothers completed questionnaires on temperament, appetite, and feeding.

Results: Infants who used a pacifier at 4 months or later (68%) had greater conditional weight gain from birth to 6 months ($p=0.01$), weight-for-length z-score at 1 year ($p<0.001$), and BMI z-score at 2 years ($p<0.001$) than infants who did not. Infants using a pacifier at ≥ 4 months were more likely to be overweight at ages 1 year (11.7% vs. 1.3%, $p=0.03$) and 2 years (20.1% vs. 7.9%, $p=0.03$). Pacifier use was associated with shorter breastfeeding duration and less responsive parent feeding styles, but these variables did not mediate the relationship between pacifiers and weight. Parent-reported temperament and appetite were unrelated to pacifier use.

Conclusions: Pacifier use beyond early infancy is associated with accelerated infant growth and toddler overweight, although the reasons for this relationship are unclear.

Keywords: child obesity; infant; pacifier; parenting; weight

Introduction

Cohort studies report that 58%–85% of infants use pacifiers,^{1–6} peaking around age 3 months.^{3,4} There is conflicting evidence regarding whether and when pacifiers should be offered, with both risks and benefits reported. For example, the Baby-Friendly Hospital Initiative’s “Ten Steps to Successful Breastfeeding” guidelines recommend against giving pacifiers to breastfeeding infants. Although observational studies have found links between pacifiers and reduced breastfeeding,⁷ a systematic review of randomized controlled trials (RCTs) of restricted vs. un-

restricted pacifier use did not report improved breastfeeding outcomes.⁸ Pacifiers may also increase risk of otitis media,⁹ dental malocclusion,¹⁰ and smoking initiation in adolescence.¹¹ In contrast, pacifiers may relieve pain during medical procedures^{12,13} and reduce sudden infant death syndrome (SIDS) risk.¹⁴ The American Academy of Pediatrics recommends offering pacifiers to infants at bedtime starting at age 3–4 weeks, after breastfeeding is established,^{15,16} whereas the American Academy of Pediatric Dentistry recommends discontinuing pacifier use by age 3 years.¹⁷ Research and recommendations on pacifier use in later infancy and early toddlerhood are lacking.

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One reason commonly cited by parents for offering pacifiers is to soothe distress.^{2,18} Pacifier use may differ by infant negative temperament, which may manifest as increased crying/fussing. Negative temperament has been reported as a risk factor for obesity, potentially due to overfeeding by parents attempting to soothe distress.¹⁹ Use of pacifiers as an alternative soothing technique could potentially moderate this relationship. Pacifier use could also vary in relation to infant appetite, which is associated with weight gain.²⁰ However, no studies have examined these potential relationships. Thus, we performed a secondary data analysis to investigate relationships between pacifier use in infancy and appetite regulation, temperament, feeding styles, and weight outcomes through age 2 years using data from the Intervention Nurses Start Infants Growing on Healthy Trajectories (INSIGHT) study, an RCT testing a responsive parenting (RP) intervention for early life obesity prevention.

Methods

Study design

Primiparous, English-speaking mothers aged ≥ 20 years and their healthy, term singleton newborns weighing ≥ 2500 g were recruited. At 10–14 days postpartum, dyads were randomized to an RP intervention or child safety control intervention.²¹ Study nurses conducted home visits at infant ages 1, 4, 6, and 9 months, and clinic visits at ages 1 and 2 years. The INSIGHT RP and control curricula have been previously described.²¹ One component of the RP curriculum focused on infant soothing. Mothers received a DVD and instruction on strategies to calm a fussy baby, including swaddling, white noise, and offering a pacifier.²² The control group received education on child safety including SIDS prevention, although pacifier use was not explicitly encouraged. The study was approved by the Penn State College of Medicine's Human Subjects Protection Office and registered at clinicaltrials.gov.

Measures

Data were collected using REDCap,²³ or on paper for mothers lacking Internet ($n=20$). Demographic data were collected at enrollment. Maternal age, prepregnancy weight, gestational weight gain, infant gestational age, sex, and birth weight and length were extracted from medical records. At randomization, mothers were asked about their current infant feeding mode, and if exclusively breastfeeding, how long they intended to breastfeed. Breast and formula feeding were also assessed at 4, 6, and 9 months through a food frequency questionnaire. Using definitions from the Infant Feeding Practices II study, infants were considered predominantly breastfed if $\geq 80\%$ of milk feeds were from breastmilk, or predominantly formula fed if $\geq 80\%$ of feeds were from formula.²⁴ Mothers also reported how old their child was when they stopped breastfeeding (breastfeeding duration).

At 2, 4, 7, and 10 months, mothers rated the frequency of pacifier use (never, rarely, sometimes, or usually) while

awake and when put to bed. Infants were considered pacifier users at each assessment if they used a pacifier at least sometimes either while awake or when put to bed. Pacifier use duration was defined as the latest time point the mother reported that her child used a pacifier. Pacifier use was also examined as a categorical variable defined by use at ≥ 4 months of age or not, as we hypothesized that associations with weight might differ between pacifier use before and after this age, when infants begin to develop self-soothing skills and greater self-regulation.²⁵ To explore intensity of pacifier use, an average intensity variable was created for both pacifier use while awake and at bedtime by assigning a numeric value to each rating (rarely = 1 through usually = 4) and averaging across the four time points.

Negative affectivity was assessed at 4 months using the Infant Behavior Questionnaire-Revised (IBQ-R)–Very Short Form ($\alpha=0.80$).²⁶ Infant appetite was assessed using the Baby Eating Behavior Questionnaire (BEBQ).²⁷ The food responsiveness ($\alpha=0.82$) and enjoyment of food ($\alpha=0.73$) subscales, and the single-item measure of general appetite, were included in analyses. A third subscale of interest, satiety responsiveness, had poor internal consistency ($\alpha=0.41$), and was not further considered. Maternal feeding styles were assessed at 6 months using the Infant Feeding Style Questionnaire (IFSQ).²⁸ Subscales used in this analysis include Pressuring-Finishing (encouragement to eat without regard to hunger/fullness cues, $\alpha=0.81$), Pressuring-Soothing (feeding in response to crying, $\alpha=0.79$), Pressuring-Cereal (use of cereal in the bottle to keep infant full, $\alpha=0.83$), Restrictive-Amount (control over amount of food eaten, $\alpha=0.74$), Restrictive-Diet Quality (control over types of foods eaten, $\alpha=0.69$), and Responsive-Satiety (feeding in response to hunger and fullness cues, $\alpha=0.77$). Other subscales demonstrated poor internal consistency or were not age appropriate.

Child weight and recumbent length were measured at each study visit, as well as standing height at 2 years. Weight was measured in duplicate to the nearest 0.01 kg on an electronic scale (Seca 354, Hanover, MD). Length and height were measured in duplicate to the nearest 0.1 cm using a portable stadiometer (Shorr Productions, Olney, MD). Weight-for-length percentiles and z-scores were calculated through 1 year using World Health Organization growth standards,²⁹ and BMI percentiles and z-scores were calculated at 2 years using the CDC growth reference.³⁰ Overweight was defined at 1 year as weight-for-length ≥ 95 th percentile per American Academy of Pediatrics guidance³¹ and at 2 years as BMI ≥ 85 th percentile per CDC cutoffs.³² Conditional weight gain (CWG), a measure of relative weight gain in early infancy, was calculated from 0 to 6 months as previously described.³³ Positive CWG scores indicate more rapid growth than the sample average; negative CWG scores indicate slower than average growth.

Data were analyzed using SAS 9.4 (SAS Institute, Cary, NC). Relationships between pacifier use and study group, demographic characteristics, and weight outcomes were assessed by linear regression, analysis of variance,

Figure 1. Mediation model for pacifier analyses. Step 1: Regression with pacifier use predicting weight outcomes is tested without the mediator (pathway c, not shown). Step 2: Regression with pacifier use predicting mediator is tested (pathway a). Step 3: Regression with mediator predicting weight outcome is tested (pathway b). If steps 1–3 reveal significant relationships, mediation is tested in Step 4: Regression with mediator (pathway b) and pacifier use (pathway c') predicting weight outcomes.

or logistic regression where appropriate. Mediation analyses were conducted using the Sobel test (Fig. 1).³⁴ All analyses were controlled for study group assignment. Statistical significance was defined as $p < 0.05$.

Results

Participant characteristics

Of the 279 mother–infant dyads who completed the first home visit, 250 had data on pacifier use through 4 months and were included in this analysis. Complete data through 10 months on 215 dyads were included in the pacifier duration analyses. Mothers were largely white, non-Hispanic, married, and college educated with 76% reporting annual household incomes $\geq \$50,000$ (Table 1). There were no demographic differences by pacifier use, nor were there differences in pacifier use by study group (data not shown).

Prevalence of pacifier use

Most infants (78.1%) used a pacifier at ≥ 1 time points. Pacifier use was most common at 2 months (Fig. 2), with 62.4% of infants using pacifiers at this age, declining to 43.2% at 10 months. Pacifier use while awake declined with infant age. At 2 months, 53.2% of infants used a pacifier while awake, declining to 22.8% at 10 months. In contrast, the percentage of infants using pacifiers at bedtime was relatively consistent ($\sim 40\%$ – 45%) across time points. Only 21.9% of infants were not using a pacifier at any assessment; 10.7% used pacifiers through 2 months, 12.6% through 4 months, 8.8% through 7 months, and 46.1% through 10 months. When dichotomized by pacifier use at 4 months or later, 68.0% of infants used a pacifier beyond early infancy.

Feeding mode at 2 weeks predicted pacifier use. A greater proportion of formula-fed infants than exclusively breastfed infants used a pacifier at 2 months (71.1% vs. 57.4%, $p = 0.05$) and 4 months (69.5% vs. 53.3%, $p = 0.01$), but not at 7 or 10 months. Daytime pacifier use followed a similar pattern, but bedtime pacifier use did not differ by initial feeding mode. A greater percentage of initially formula-fed infants used a pacifier at 4 months or later (76.5% vs. 62.5%,

$p = 0.02$), but there was no difference in pacifier use duration by initial feeding mode.

Pacifier use and weight outcomes

There was a significant positive association between pacifier use duration and weight-for-length z-score at 1 year ($R^2 = 0.03$, $p = 0.005$) and BMI z-score at 2 years ($R^2 = 0.05$, $p = 0.001$) (Fig. 3). Similar results were observed using percentiles (data not shown). Pacifier use duration was also positively associated with overweight at 2 years [odds ratio (OR) = 1.16 (95% confidence interval {CI} 1.04–1.28) per month of use, $p = 0.007$]. Infants who used pacifiers at 4 months or later had more rapid weight gain from 0 to 6 months ($p = 0.01$), higher weight-for-length z-scores at 1 year ($p < 0.001$), and higher BMI z-scores at 2 years ($p < 0.001$) than those who did not use pacifiers (Fig. 4). Among those using pacifiers at 4 months or later, 11.7% were overweight at 1 year and 20.1% at 2 years compared with 1.3% ($p = 0.03$) and 7.9% ($p = 0.03$) of those who did not use pacifiers beyond early infancy (Fig. 5). Average intensity of pacifier use at bedtime was positively associated with weight-for-length z-score at 1 year ($R^2 = 0.02$, $p = 0.03$), BMI z-score at 2 years ($R^2 = 0.03$, $p = 0.006$), and risk of overweight at 2 years (OR = 1.47, CI 1.07–2.01). Similar, but nonsignificant ($p < 0.10$), patterns were observed with pacifier use intensity while awake. There were no significant interactions between study group and pacifier use, and relationships between pacifier use and weight were not attenuated by controlling for study group assignment. Adjusting for initial feeding mode also did not attenuate results (data not shown).

Hypothesized mediators

Infants who used pacifiers at 4 months or later were less likely to be predominantly breastfed at 9 months, and were breastfed for a shorter duration (mean $\pm$ standard deviation 6.7 ± 5.8 vs. 8.8 ± 6.4 months, $p = 0.02$), than those who did not use pacifiers (Table 2). However, breast/formula-feeding variables were not associated with weight outcomes and did not mediate the relationship between pacifier use and

Table 1. Demographic Characteristics

	Participants (<i>n</i> = 250)
Maternal age (years), mean (SD)	29.1 (4.6)
Prepregnancy BMI (kg/m ²), mean (SD)	25.4 (5.3)
Gestational weight gain (kg), mean (SD)	15.3 (6.2)
Household income, <i>n</i> (%)	
<\$10,000	8 (3.2)
\$10,000–24,999	17 (6.8)
\$25,000–49,999	24 (9.6)
\$50,000–74,999	68 (27.2)
\$75,000–99,999	52 (20.8)
≥\$100,000	70 (28.0)
Don't know/refuse to answer	11 (4.4)
Maternal education, <i>n</i> (%)	
High school or less	24 (9.6)
Some college	61 (24.4)
College graduate	95 (38.0)
Postgraduate	70 (28.0)
Married, <i>n</i> (%)	197 (78.8)
Race, <i>n</i> (%)	
Black	11 (4.4)
White	227 (90.8)
Native Hawaiian/Pacific Islander	1 (0.4)
Asian	8 (3.2)
Other	3 (1.2)
Hispanic, <i>n</i> (%)	15 (6.0)
Exclusively breastfed at 2 weeks, <i>n</i> (%)	152 (60.8)
Birth weight (kg), mean (SD)	3.4 (0.4)
Gestational age (weeks), mean (SD)	39.5 (1.2)
Infant sex female, <i>n</i> (%)	125 (50.0)
SD, standard deviation.

Figure 2. Prevalence of pacifier use among infants participating in the Intervention Nurses Start Infants Growing on Healthy Trajectories study (*n* = 250).

in response to crying, $p < 0.001$) and Responsive-Satiety (*i.e.*, feeding in accordance with child hunger/satiety cues, $p = 0.008$). Mothers of infants who used pacifiers at 4 months or later had significantly lower scores on these scales (Table 2) as well as significantly higher scores on the Restrictive-Amount scale ($p = 0.01$). Pressuring-Soothing score was not significantly related to infant weight. The Responsive-Satiety scale was negatively associated with overweight at 2 years (OR = 0.46, CI 0.22–0.93, $p = 0.03$), whereas Restrictive-Amount was positively associated with all weight outcomes except for overweight at 2 years, but these variables did not mediate the relationship between pacifier use and weight outcomes. None of the other IFSQ scales, or the BEBQ or IBQ-R scores differed by pacifier use (Table 2), nor did they mediate the associations between pacifier use and weight.

Discussion

In this secondary analysis, pacifier use was associated with more rapid infant weight gain from 0 to 6 months and greater rates of overweight at ages 1 and 2 years. Although pacifier use was associated with shorter breastfeeding duration and less responsive feeding styles, these factors did not explain the relationship between pacifier use and infant weight. Two other hypothesized mediators, temperament and appetite, were not associated with pacifier use.

Three previous publications have examined associations between pacifiers and child weight. Using data from English infants born between 1911 and 1930, Gale and Martyn found that infants who used a pacifier weighed less at age 1 year than those who did not use a pacifier.³⁵ However, during this era, attitudes toward pacifiers were more negative and usage is considerably lower than is observed today.³⁵ It is unlikely that children who used pacifiers a century ago are representative of modern-day pacifier users. In a sample of 3 to 7-year-old children, there was no significant difference in BMI percentile between those who had used a pacifier in infancy and those who had not used a pacifier.³⁶ Finally, a recent publication reported

weight outcomes. There were also no significant interactions between breast/formula-feeding variables and pacifier use, suggesting that the relationship between pacifier use and weight does not differ by feeding mode. Pacifier use duration was not associated with breast/formula-feeding variables. Among mothers who were exclusively breastfeeding at 2 weeks ($n = 101$), there were no significant differences by pacifier use in the percentage of mothers meeting/exceeding their goals for duration of any breastfeeding.

Pacifier use duration was negatively associated with two feeding styles—Pressuring-Soothing (*i.e.*, feeding

Figure 3. Pacifier use duration (months) is positively associated with (A) weight-for-length z-score at 1 year ($p=0.005$) and (B) BMI z-score at 2 years ($p=0.001$). Values are mean $\pm$ standard error.

Figure 4. Pacifier use at 4 months or later is associated with greater conditional weight gain from 0 to 6 months ($p=0.01$), greater weight-for-length percentile at 1 year ($p<0.001$), and greater BMI percentile at 2 years ($p<0.001$). Values are mean $\pm$ standard error.

Figure 5. A greater percentage of infants who used pacifiers at 4 months or later than those who did not use pacifiers was overweight at 1 year (weight-for-length ≥ 95 th percentile) and 2 years (BMI ≥ 85 th percentile). * $p<0.05$ for difference between pacifier users and nonusers.

that in a predominantly formula-fed, African American sample, consistent pacifier use through 9 months of age was associated with a lower risk of BMI ≥ 85 th percentile at 9–15 months,³⁷ in contrast to our findings. However, unlike our analyses, this study did not examine differences by timing of pacifier use (earlier vs. later infancy). These conflicting results suggest that relationships between pacifiers and weight may differ depending on timing of use, highlighting the need for additional longitudinal studies.

Pacifier use intensity at bedtime was associated with weight outcomes at 1 and 2 years. Associations between pacifier use intensity while awake and weight outcomes followed similar patterns, but did not reach statistical significance. Reasons for offering a pacifier at bedtime and while awake likely differ, which could have contributed to these results; however, we did not assess mothers' reasons for offering pacifiers. Future research will need to better quantify pacifier use intensity as well as the reasons for offering pacifiers to explore potential differential effects of daytime and nighttime pacifier use.

Pacifier use at 4 months or later was associated with lower rates of predominant breastfeeding and fewer total months of any breastfeeding. However, among mothers who were exclusively breastfeeding at 2 weeks, pacifier use was not associated with the likelihood of meeting their goal for duration of any breastfeeding. These data are consistent with other reports that pacifiers do not interfere with established breastfeeding.^{8,38,39} Pacifier use was more common among those who were formula fed at 2 weeks, but because we did not collect data on pacifier use during the neonatal period, it is unknown whether pacifier use influenced mothers' early feeding decisions or breastfeeding success. Although breast/formula feeding differed by pacifier use, these variables

Table 2. Hypothesized Correlates of Pacifier Use

	Pacifier use beyond early infancy (4 months or later)		
	Yes (n = 170)	No (n = 80)	p ^a
Feeding mode, n (%)			
2 weeks			0.02
Exclusively breastfed	95 (55.9)	57 (71.3)	
Formula fed	75 (44.1)	23 (28.8)	
4 months			0.10
Predominantly breastfed ^b	74 (43.5)	46 (58.2)	
Breast and formula fed	27 (15.9)	9 (11.4)	
Predominantly formula fed ^c	69 (40.6)	24 (30.4)	
6 months			0.19
Predominantly breastfed	56 (34.4)	37 (46.3)	
Breast and formula fed	25 (15.3)	10 (12.5)	
Predominantly formula fed	82 (50.3)	33 (41.3)	
9 months			0.045
Predominantly breastfed	47 (28.7)	35 (43.8)	
Breast and formula fed	17 (10.4)	4 (5.0)	
Predominantly formula fed	100 (61.0)	41 (51.3)	
Any breastfeeding duration (months), mean (SD) ^d	6.7 (5.8)	8.8 (6.4)	0.01
Exclusive breastfeeders at 2 weeks who met or exceeded their breastfeeding duration goal, n (%)	61 (65.6)	40 (71.4)	0.45
Temperament (4 months), mean (SD) ^e			
Negative affect	3.4 (0.9)	3.4 (0.9)	0.93
Appetite (10 months), mean (SD) ^f			
Food responsiveness	2.1 (0.7)	2.0 (0.7)	0.36
Enjoyment of food	4.4 (0.6)	4.5 (0.4)	0.10
General appetite rating	3.7 (1.0)	3.7 (1.1)	0.60
Feeding styles (6 months), mean (SD) ^g			
Pressuring-Finishing	2.0 (0.7)	2.0 (0.7)	0.83
Pressuring-Soothing	1.9 (0.7)	2.1 (0.9)	0.004
Pressuring-Cereal	1.6 (0.8)	1.5 (0.7)	0.61
Restrictive-Amount	3.0 (1.0)	2.6 (1.0)	0.01
Restrictive-Diet Quality	3.9 (0.7)	3.9 (0.7)	0.81
Responsive-Satiety	4.5 (0.5)	4.7 (0.4)	0.01

^aAnalyses controlled for study group.^b≥80% of milk feeds from breastmilk.^c≥80% of milk feeds from formula.^dAssessed through 18 months.^eInfant Behavior Questionnaire, scale 1–7.^fBaby Eating Behavior Questionnaire, scale 1–5.^gInfant Feeding Style Questionnaire, scale 1–5.

did not attenuate the relationship between pacifier use and infant weight.

Three infant feeding styles were associated with pacifier use. Lower scores on the Pressuring-Soothing subscale among pacifier users suggest that parents may use pacifiers instead of feeding to soothe crying. Use of food to soothe has been associated with greater infant weight⁴⁰; however, we did not observe any relationship between weight and Pressuring-Soothing scores. Lower scores on the Responsive-Satiety subscale suggest that parents who use pacifiers may exert more control over when and how much their infants eat. Victora et al. observed that mothers who used pacifiers more intensely demonstrated more controlling behaviors during breastfeeding, such as not allowing the infant to decide when the feeding was over.³ Other studies have reported that breastfed infants who used pacifiers had fewer feedings per day and longer stretches between feeding,⁴¹ and mothers report offering a pacifier to stretch time between feeds² or to reduce frequent feedings.³⁷ Pacifier use may be a marker of a less responsive feeding style, which may increase risk of overweight.⁴² The Restrictive-Amount subscale was also associated with pacifier use at 4 months or later, and with weight independently of pacifier use. Previous studies have noted an association between restriction and higher weight, possibly due to a bidirectional relationship where parents become more restrictive in response to higher child weight.^{43,44} We assessed feeding styles at 6 months, when pacifier users were already exhibiting faster weight gain, and parents may have offered pacifiers in place of food as a restriction strategy.

Negative temperament at 4 months was not associated with pacifier use. In 2 to 4-month-old infants, Kelmanson et al.⁴⁵ assessed temperament using the Early Infant Temperament Questionnaire. Rhythmicity, a measure of regularity of physiologic functions such as hunger and sleep, was greater in pacifier users than in nonusers; however, other dimensions of temperament, including mood, did not differ by pacifier use. In an RCT, infants whose mothers were instructed to avoid pacifiers had fewer episodes of crying per day at 4 weeks; however, there was no difference in total crying duration or episodes of unsoothable crying, and no differences in any measures of crying at 6 and 9 weeks.⁴⁶ Given the high prevalence of pacifier use in ours and other cohorts,¹⁻⁵ it seems that pacifier use is a normative behavior rather than a response to infant negativity. Few studies have investigated relationships between appetite and pacifiers. Kaymaz et al. found no difference in history of pacifier use between 3 to 7-year-old children with poor appetite and healthy controls.³⁶ Our data suggest that parent-reported appetite in infancy is also not related to pacifier use.

A limitation of this analysis is that these data are from an RCT of an intervention including guidance to use a pacifier to soothe infant distress. However, there was no difference by intervention group in pacifier use, and all analyses were controlled for group assignment. Our sample is limited to first-born infants, who are both more likely to use pacifiers^{4,5,47} and to become overweight,^{48,49} and thus these find-

ings may not be applicable to all infants. Another limitation is that when assessing pacifier use frequency, we did not clearly define for mothers what “rarely,” “sometimes,” or “usually” meant. Leaving this open to interpretation by mothers could potentially introduce bias into our measures. Future studies will need to more carefully quantify pacifier use. Finally, pacifier use beyond 10 months was not assessed, so we were unable to explore effects of pacifier use into toddlerhood.

In summary, in this secondary analysis, pacifier use outside of early infancy was associated with more rapid infant growth and toddler overweight, although hypothesized mediators did not explain this relationship. Future studies are needed to elucidate mechanisms linking pacifiers to weight, and to explore the effects of pacifier use into toddlerhood to better characterize the benefits and risks of pacifiers.

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Author Disclosure Statement

No competing financial interests exist.

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