

# Breastfeeding Duration and Weight Gain Trajectory in Infancy

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abstract

**BACKGROUND AND OBJECTIVES:** Short breastfeeding duration may exacerbate accelerated early growth, which is linked to higher obesity risk in later life. This study tested the hypothesis that infants at higher risk for obesity were more likely to be members of a rising weight-for-length (WFL) z score trajectory if breastfed for shorter durations.

**METHODS:** This prospective, observational study recruited women from an obstetric patient population in rural central New York. Medical records of children born to women in the cohort were audited for weight and length measurements ( $n = 595$ ). We identified weight gain trajectories for infants' WFL z scores from 0 to 24 months by using maximum likelihood latent class models. Individual risk factors associated with weight gain trajectories ( $P \leq .05$ ) were included in an obesity risk index. Logistic regression analysis was performed to investigate whether the association between breastfeeding duration (<2 months, 2–4 months, >4 months) and weight gain trajectory varied across obesity risk groups.

**RESULTS:** Rising and stable weight gain trajectories emerged. The obesity risk index included maternal BMI, education, and smoking during pregnancy. High-risk infants breastfed for <2 months were more likely to belong to a rising rather than stable weight gain trajectory (odds ratio, 2.55; 95% confidence interval, 1.14–5.72;  $P = .02$ ).

**CONCLUSIONS:** Infants at the highest risk for rising weight patterns appear to benefit the most from longer breastfeeding duration. Targeting mothers of high-risk infants for breastfeeding promotion and support may be protective against overweight and obesity during a critical window of development.



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**WHAT'S KNOWN ON THIS SUBJECT:** Although we know breastfeeding is beneficial and infant weight gain can predict obesity later in life, the relationship between breastfeeding duration and infant weight gain patterns among populations exhibiting high risk for obesity is unexplored.

**WHAT THIS STUDY ADDS:** This study demonstrates the greater odds of increased infant weight gain for infants who breastfed for shorter durations among those exposed to a high number of maternal biopsychosocial risk factors for obesity.

Breastfeeding bestows many well-documented benefits on mother and child.<sup>1-3</sup> However, evidence supporting the relationship between breastfeeding and child obesity development is controversial and less conclusive.<sup>4,5</sup> Elevated weight gain compared with infant growth standards is linked with higher risk of child and adult overweight or obesity.<sup>6-8</sup> Several potential mechanisms explain how breastfeeding may protect against elevated infant weight gain, including better appetite control and lower protein intake among breastfed infants than among formula-fed infants.<sup>9-11</sup> Isolating the effect of optimal breastfeeding behavior on obesity development is problematic for researchers, because breastfeeding clusters with other behaviors (eg, higher education)<sup>12</sup> that protect against obesity. Therefore, teasing apart predictors of childhood obesity is challenging, and often cumulative effects of risk factors are more important than the impact of any 1 factor taken alone.<sup>13-15</sup>

The purpose of this study was to address whether shorter breastfeeding duration influenced the odds of rising infant weight gain patterns among children with differing risk profiles for obesity. This study had 3 specific objectives: to identify infants with rising weight gain trajectories from 0 to 24 months, to develop a risk index of factors associated with rising infant weight gain trajectories, and to test the hypothesis that infants exhibiting high obesity risk were especially susceptible to membership in a rising weight gain trajectory if breastfed for shorter durations.

## METHODS

### Population and Sample

The Bassett Mothers Health Project was a prospective, observational study that recruited women from an obstetric patient population in rural central New York. Recruitment

procedures, sample selection, and data collection processes for the prenatal cohort ( $n = 622$ ) are described elsewhere.<sup>16-18</sup> Prenatal cohort data consisted of responses to survey questionnaires mailed to participants at 5 time points from pregnancy through 2 years postpartum. Questionnaires addressed nutrition, weight, and psychosocial factors. In addition to survey data, mothers' medical charts were audited to obtain demographic data, weight and height measurements, health and psychosocial history, and socioeconomic information.

Medical records of children born to women in the prenatal cohort were audited for weight and length or height measurements from birth to ~15 years of age. This study used measurements from birth to 2 years among infants with full-term gestation births ( $\geq 37$  weeks;  $n = 595$ ).

Ethical permission for this study was provided by the institutional review boards at Cornell University and Mary Imogene Bassett Hospital.

### Weight Gain Trajectories

We used measured heights and weights for each child obtained through medical chart audits to calculate WFL  $z$  scores by using the World Health Organization (WHO) 2007 growth standards.<sup>19</sup> Measurements were opportunistically captured during Bassett Healthcare Network clinic visits. All clinics used a standard protocol for obtaining heights and weights: Children  $< 2$  years of age were laid on the paper-covered scale, and lines were drawn at the head and heel once the child was lying flat. Measurement frequency and timing were different for each child but were dictated largely by the well examination visit schedule. The average number of WFL measurements per child in the sample was 7 (2 SD). WFL  $z$  score, rather than WFL, was used to build trajectories in an effort to illustrate the deviation of our sample from the

WHO's standard trajectories, which are meant to show optimal child growth from birth to 24 months. We used maximum likelihood longitudinal latent class modeling techniques to identify weight gain trajectories and classify children.

### Obesity Risk Index

Individual risk factors associated with rising weight gain trajectories ( $P \leq .05$ ) as demonstrated by bivariate analysis were included in an obesity risk index. Variables tested for inclusion in the risk index were maternal BMI,<sup>20-22</sup> gestational weight gain,<sup>20,23-25</sup> maternal education,<sup>26,27</sup> smoking,<sup>20,28-30</sup> social support,<sup>31</sup> food insecurity during pregnancy,<sup>32-34</sup> and stress at 1 year postpartum.<sup>34</sup>

Maternal BMI was calculated from measurements taken at the initial prenatal visit during the first trimester and categorized as normal or underweight ( $< 25$ ), overweight ( $25 - < 30$ ), or obese ( $\geq 30$ ).<sup>35</sup> A detailed description of gestational weight gain methods is given elsewhere.<sup>20</sup> Briefly, we determined weight gain by subtracting the first measured weight in the first trimester of pregnancy from the weight at the last prenatal care visit, which was generally within 1 week of delivery. The 2009 Institute of Medicine BMI categories and gestational weight gain guidelines were used to determine gestational weight gain category.<sup>36</sup> Gestational weight gain was a categorical variable defined as 2 groups: excessive and adequate or inadequate.

Maternal education, smoking, social support, food insecurity during pregnancy, and stress at 1 year postpartum were assessed by self-report on mailed questionnaires. Maternal education was categorized as high school or less, some college, or college graduate or more at the time of prenatal data collection. Smoking during pregnancy was categorized as either yes or no. Social support was categorized as low,

medium, or high and reflected responses to 2 questions presented during pregnancy: "How often during the last week did friends or relatives give you practical help?" and "How many people (not including your husband or partner) could you call on for help if you are having trouble?" Food insecurity was categorized as yes or no based on 3 questions asked on a nutrition questionnaire during pregnancy. To qualify as food insecure, a participant must have run out of food or needed help obtaining food or not been able to afford to eat as she should.<sup>37</sup> Stress at 1 year postpartum was categorized as either yes or no for having the response "very stressful" to the question "How stressful would you say your life is right now?"

Each significant risk factor in the index was assigned a point value of 1, indicating an equal weight for each factor, and a cumulative risk score was calculated for each infant. The distribution of risk factors was examined and cutoffs were established to designate low-, medium-, and high-risk infants.

### Breastfeeding Duration

We determined breastfeeding duration by using infant feeding survey questions presented at 6 weeks, 6 months, 1 year, and 2 years postpartum. Any breastfeeding duration was categorized as never, <2 months, 2 to 4 months, or >4 months. We performed bivariate analyses to elucidate the relationship between breastfeeding duration and infant growth trajectories (outcome variable) and individual risk factors included in the obesity risk index (covariates).

### Statistical Analyses

#### Weight Gain Trajectories

We identified group-based trajectories for infant WFL status from 0 to 24 months by using maximum likelihood latent class models in PROC TRAJ,<sup>38-41</sup> a procedural command in SAS (SAS Institute, Inc, Cary, NC). The purpose

of this modeling was to characterize the optimal number of trajectories over time based on statistical and public health criteria. In an effort to focus our analysis on the issue of overweight and obesity development and maintain as much statistical power as possible, we chose to combine rising trajectories into 1 group and stable trajectories into another. Because rising trajectories indicate accelerated growth beyond what the WHO deems optimal, our analysis compared predictors of accelerated and stable growth. Models with 1 to 8 groups were estimated for weight gain trajectory, beginning with the simplest model. Model fit for each of the subsequent models was first statistically evaluated based on recommended change in Bayesian information criterion score, which tends to favor more parsimonious models than likelihood ratio tests.<sup>38</sup> After review of model statistics, groups were visually inspected to ensure that distinctive features of the data were summarized in as parsimonious a fashion as possible. The 2 main outputs from the trajectory models were shape of trajectory and probability of group membership. The program used the latter to classify individuals into trajectory groups.<sup>41</sup> Groups were condensed according to whether they were rising over time or remained stable. Groups were then used in the analysis as categorical variables. PROC TRAJ provides a helpful illustration of how the sample's weight gain trajectory groups changed over time. The same models that determined group trajectory shape (based on infant data) and probabilities of membership were used to visually display groups and their 95% confidence intervals.

Missing data analysis yielded 3 groups of children: those with frequent measurements from birth to 2 years ( $n = 438$ ), declining number of measurements from birth to 2 years ( $n = 40$ ), and almost no

measurements beyond birth ( $n = 117$ ). The last group was excluded from analysis because of the paucity of measurements and did not differ from the remaining 2 groups by income, maternal education, maternal BMI, or maternal smoking. To determine whether exclusion of the declining measures group changed the proportion of children in each trajectory group with certain obesity risk characteristics, we ran a complete case model ( $n = 438$ ) and a full model ( $n = 478$ ). Neither model differed with respect to maternal education ( $P = .30$ ), maternal BMI ( $P = .13$ ), or maternal smoking during pregnancy ( $P = .35$ ). Therefore, we think the complete case sample is an appropriate sample for this analysis.

#### Multivariate Logistic Regression

Logistic regression analysis was performed to investigate whether early-life obesity risk moderated the association between breastfeeding duration and weight gain trajectory. Maternal age at time of delivery (continuous variable) and infant ponderal index at birth (above or below the median) were included in the analysis as control variables because they are potential confounders in examining the relationship between obesity risk and weight gain in early life. SAS version 9.3 was used for all analyses.

### RESULTS

Characteristics of the original study and analysis samples are shown in Table 1. Although small differences emerged for educational attainment ( $P = .05$ ), social support ( $P = .08$ ), and infant ponderal index ( $P = .09$ ), we think this is a reasonable population-based sample in which to explore our hypothesis.

#### Weight Gain Trajectories

Fig 1 shows 4 weight gain trajectories that emerged from latent class modeling. Two trajectories categorized for their tendency to rise over time were combined for subsequent analyses

**TABLE 1** Comparison of Characteristics Between Original and Analysis Sample

Maternal Characteristics and Behaviors	Original Sample, <i>n</i> = 595	Complete Case Sample, <i>n</i> = 438	<i>P</i> <sup>a</sup>
	<i>n</i> (%)	<i>n</i> (%)	
Breastfeeding duration			.63
<2 mo	198 (34.9)	152 (38.3)	
2–4 mo	50 (8.8)	36 (20.1)	
>4 mo	319 (56.3)	234 (41.6)	
Missing	28	16	
BMI category			.23
Obese	139 (23.4)	95 (21.7)	
Overweight	156 (26.2)	120 (27.4)	
Normal	300 (50.4)	223 (50.9)	
Gestational wt gain			.53
Excessive	282 (47.4)	211 (48.2)	
Adequate or inadequate	313 (52.6)	227 (51.8)	
Educational attainment			.05*
High school or less	229 (38.5)	167 (38.1)	
Some college	158 (26.6)	107 (24.4)	
College or more	208 (34.9)	164 (37.4)	
Smoking during pregnancy			.26
Yes	118 (19.8)	82 (18.7)	
No	477 (80.2)	356 (81.3)	
Very stressed at 1 y postpartum			.72
Yes	110 (22.9)	82 (22.5)	
No	370 (77.1)	282 (77.5)	
Missing	115	74	
Social support			.08*
Low	166 (28.2)	115 (26.6)	
Medium	307 (52.2)	224 (51.7)	
High	116 (19.7)	94 (21.7)	
Missing	6	5	
Food insecure during pregnancy			.37
Yes	91 (19.8)	73 (20.7)	
No	368 (80.2)	279 (79.3)	
Missing	136	86	
	Mean ± SD	Mean ± SD	<i>P</i> <sup>b</sup>
Age at time of delivery	153 (25.7)	110 (25.1)	.76
Child Characteristics	<i>n</i> (%)	<i>n</i> (%)	<i>P</i> <sup>a</sup>
Ponderal index			.09*
Above the median	232 (39.0)	162 (37.0)	
Below the median	363 (61.0)	276 (63.0)	

\**P* < .15.<sup>a</sup> $\chi^2$  analysis.<sup>b</sup>Satterthwaite method used because samples have unequal variances.

(A: high-rising, 19.8% participants; B: low-rising, 27.9%). The 2 remaining trajectories were categorized for their tendency to remain stable over time and also combined for subsequent analyses (C: mid-stable, 23.4%; D: low-stable, 28.9%).

### Obesity Risk Index

Table 2 shows bivariate relationships between maternal characteristics and weight gain trajectory. Children with rising trajectories were more likely to have mothers who were obese (57.9%

vs 42.1%; *P* = .03), had less than a high school education (56.9% vs 43.1%; *P* = .01), and smoked during pregnancy (58.5% vs 41.5%; *P* = .03) when compared with children with stable trajectories. Children were assigned obesity risk scores based on the number of significant risk factors to which they were exposed. Based on risk score distribution across our sample (range, 0–3; mean, 1.06; SD, 0.87), scores were categorized as low (0 risk factors; *n* = 128, 29.2% of sample), medium (1 risk factor;

*n* = 181, 41.3%), or high (2 or 3 risk factors; *n* = 129, 29.5%).

### Obesity Risk Factors and Breastfeeding Behaviors

Table 3 shows bivariate relationships between individual risk factors and breastfeeding duration. Education (*P* < .001) and smoking during pregnancy (*P* = .009) were associated with breastfeeding duration. A higher proportion of children breastfed for <2 months had mothers with a high school education or less compared with children breastfed for >4 months (51.5% vs 31.7%). Similarly, a higher proportion of children breastfed for <2 months had mothers who smoked during their pregnancy when compared with children breastfed for >4 months (52.4% vs 31.7%).

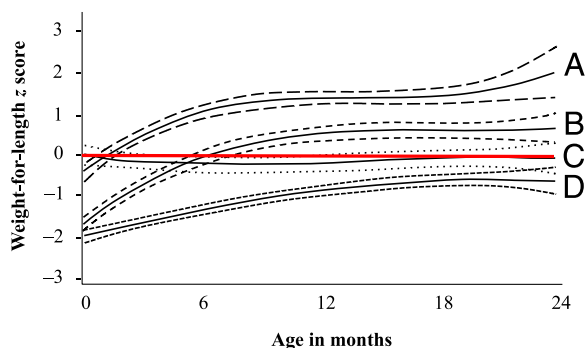
### Obesity Risk, Breastfeeding, and Weight Gain Trajectories

Table 4 shows the odds of being in a rising weight gain trajectory, as compared with a stable trajectory, depending on risk exposure and breastfeeding duration. Children who experienced high risk of obesity and breastfed for <2 months were 2.55 (95% CI, 1.14–5.72) times more likely to belong to a rising growth trajectory than children at high risk breastfed for >4 months (*P* = .02).

### DISCUSSION

This study showed that among infants with high levels of obesity risk, those breastfed for shorter durations were more likely to be in a rising weight gain trajectory than infants breastfed for longer durations. Several studies have investigated the relationship between breastfeeding and increased infant weight gain. However, to our knowledge no other study addresses how the interaction between breastfeeding duration and other obesity risk factors is associated with weight gain trajectories.

Primarily, our study aimed to understand how breastfeeding duration interacted with maternal



**FIGURE 1**

WFL z score trajectories with 95% confidence intervals (dotted lines) that emerged from latent class modeling. A, High-rising trajectory containing 19.8% of analysis sample. B, Low-rising trajectory containing 27.9% of analysis sample. C, Mid-stable trajectory containing 23.4% of analysis sample. D, Low-stable trajectory containing 28.9% of analysis sample. The red solid line is added for reference to WFL z score equal to 0.

risk exposures to affect infant weight gain. Two studies found low maternal education and low socioeconomic status associated with greater weight gain and higher prevalence of rapid growth in the first year of life

compared with infants of more highly educated and high-socioeconomic status mothers.<sup>42,43</sup>

The literature supports the inclusion of maternal BMI, educational attainment, and smoking during

pregnancy in our obesity risk index, which included all factors associated with infant weight change. Deierlein et al<sup>44</sup> found that prepregnancy BMI and gestational weight gain were associated with infant size at 6 months, but maternal BMI was not associated with rapid weight gain. Van Den Berg et al<sup>42</sup> found that low maternal education was associated with greater weight gain, but not WFL gain, in the first year of life. Oyama et al<sup>45</sup> concluded that maternal prepregnancy smoking and drinking contributed to rapid infant weight gain in the first 1 to 18 months of life.

Unlike Deierlein et al,<sup>44</sup> we found that gestational weight gain was not associated with infant growth in our sample. We categorized gestational weight gain as excessive versus inadequate or adequate, thinking excessive weight gain detrimental and deserving of a point in our index. Ehrenthal et al<sup>46</sup> showed that only inadequate gestational weight gain was significantly associated with a higher BMI z score at age 4 years after adjusting for prepregnancy BMI and other covariates, suggesting that inadequate gestational weight gain contributes to increased adiposity. However, descriptive statistics indicated that inadequate gainers in our cohort engaged more often in healthy behaviors and may have gained inadequately because of health consciousness.

Our analysis sought to expand these findings to examine more potential risk factors for elevated infant weight gain. In addition, children in the high-risk category exemplify the interplay of biopsychosocial risk factors that lead to poor health. In our sample, children at high risk were more likely to have mothers who were low income (68% vs 24% for low-risk children), <25 years old (43% vs 13%), and food insecure during pregnancy (41% vs 7.5%).

Regarding breastfeeding and infant growth, Oyama et al<sup>45</sup> showed that breastfeeding was associated with

**TABLE 2** Bivariate Relationships Between Individual Risk Factors for Obesity and WFL z Score Growth Trajectories

Maternal Characteristics, n (%)	Growth Trajectory		P <sup>a</sup>
	Rising	Stable	
Breastfeeding duration			.12
<2 mo	88 (53.3)	77 (46.7)	
2-4 mo	43 (49.4)	44 (50.6)	
>4 mo	79 (42.5)	107 (57.5)	
BMI category			.03*
Obese	55 (57.9)	40 (42.1)	
Overweight	61 (50.8)	59 (49.2)	
Normal	94 (42.2)	129 (57.8)	
Gestational wt gain			.35
Excessive	106 (50.2)	105 (49.8)	
Adequate and inadequate	104 (45.8)	123 (54.2)	
Educational attainment			.01*
High school or less	95 (56.9)	72 (43.1)	
Some college	46 (43.0)	61 (57.0)	
College or more	69 (42.1)	95 (57.9)	
Smoking during pregnancy			.03*
Yes	48 (58.5)	34 (41.5)	
No	162 (45.5)	194 (54.5)	
Very stressed at 1 y postpartum			.21
Yes	53 (53.5)	46 (46.5)	
No	157 (46.3)	182 (53.7)	
Social support			.76
Low	57 (49.6)	58 (50.4)	
Medium	111 (48.5)	118 (51.5)	
High	42 (44.7)	52 (55.3)	
Food insecure during pregnancy			.30
Yes	46 (52.9)	41 (47.1)	
No	164 (46.7)	187 (53.3)	

\*P < .05.

<sup>a</sup>χ<sup>2</sup> analysis.

**TABLE 3** Bivariate Relationships Between Individual Risk Factors for Obesity and Breastfeeding Duration

Maternal characteristics, n (%)	Breastfeeding Duration			P <sup>a</sup>
	<2 mo	2–4 mo	>4 mo	
BMI category				.43
Obese	41 (43.2)	21 (22.1)	33 (34.7)	
Overweight	47 (39.2)	23 (19.2)	50 (41.6)	
Normal	77 (34.5)	43 (19.3)	103 (46.2)	
Educational attainment				<.001*
High school or less	86 (51.5)	28 (16.8)	53 (31.7)	
Some college	40 (37.4)	21 (19.6)	46 (43.0)	
College or more	39 (23.8)	38 (23.2)	87 (53.0)	
Smoking during pregnancy				.009*
Yes	43 (52.4)	13 (15.9)	26 (31.7)	
No	122 (34.3)	74 (20.8)	160 (44.9)	

\*P < .05.

<sup>a</sup>χ<sup>2</sup> analysis.

faster growth in the first month of life and slower growth over the first 18 months. Although their findings are consistent with breastfeeding literature and WHO growth curves, which indicate breastfed infants grow faster in the first few months of life and are then surpassed by formula-fed infants as they approach 1 year,<sup>47–50</sup> Oyama et al did not investigate the interaction between maternal risk factors and breastfeeding behavior as predictors of infant growth. Miharshahi et al<sup>51</sup> found that formula feeding and feeding on a schedule rather than on demand were associated with rapid

infant weight gain. Although it was informative, all breastfeeding categories were grouped together in their analysis, and the impact of varying durations on infant growth was unclear. This finding is especially important given that 75% of US women initiate breastfeeding, but only 49% are partially or exclusively breastfeeding at 6 months.<sup>52</sup> Thus, our analyses are different, both conceptually and statistically.

Our sample is an understudied, at-risk, rural sample with higher rates of overweight and obesity than other suburban populations. However, generalizability of this study is limited to similar rural and predominantly white populations. The predominantly white population may explain why a majority of our sample's weight gain trajectories originate at or below the WHO growth curve mean, possibly because of their taller stature compared with the population used to develop WHO growth curves.

Another limitation was that our sample size restrained the types of analyses we could perform. Ideally, we would not have combined rising and stable weight gain trajectories, but regression model stability deteriorated because of sample size. In addition, we defined obesity risk categorically rather than continuously because our objective was to examine

breastfeeding's effect on children of similar risk. Because we lumped only 2 groups together (children with 2 or 3 risk factors), we did not lose much variation in the distribution but gained an ability to easily display and quantify breastfeeding impact on children in the same risk category. Finally, our study did not distinguish between exclusive and partial breastfeeding, and research shows that exclusive and partial breastfeeding,<sup>53</sup> as well as early supplementation with solids,<sup>54,55</sup> vary in terms of childhood weight outcomes.

Strengths of this study include measurement of maternal and infant heights and weights by medical professionals and use of weight trajectories instead of weight differences between 2 time points, as is common in the literature.<sup>42,44</sup> Although weight gain trajectories in our study were ultimately categorized as rising or stable, the manner in which we assigned trajectory membership to each infant was more reflective of nonlinear growth than differences in WFL measurements at 2 time points.

Another strength of our study is that the questionnaires were designed to ask in-depth questions about breastfeeding, providing a reliable measure of breastfeeding behavior. Finally, use of a risk index captured the vulnerability of a population exposed to a variety of risk factors in a single measure, making it useful in public health screening. In practice, risk can be analyzed in more depth by evaluating individual factors to see what is driving overall risk, enabling population-specific risk profiles that can help in effective development of public health promotion.

To build the literature and elucidate the relationship between various risk factors and infant weight gain, future research involving infant weight gain should use weight gain trajectories rather than methods assuming linear growth over time. Although some phases in child growth are linear,

**TABLE 4** Odds of Being in a Rising Wt-Gain Trajectory Compared With a Stable Trajectory Depending on Obesity Risk

	Odds Ratio (95% Confidence Interval) <sup>a</sup>	P
High risk		
<2 mo	2.55 (1.14–5.72)	.02*
2–4 mo	1.43 (0.48–3.85)	.53
>4 mo	Reference	
Medium risk		
<2 mo	1.64 (0.82–3.26)	.16
2–4 mo	1.82 (0.84–3.96)	.13
>4 mo	Reference	
Low risk		
<2 mo	0.42 (0.16–1.11)	.08
2–4 mo	0.92 (0.36–2.34)	.87
>4 mo	Reference	

\*P < .05.

<sup>a</sup>Controlling for maternal age (continuous) and ponderal index (above or below median).

many are not.<sup>56</sup> Therefore, investigations using linear representation of growth over phases of nonlinear growth may draw inaccurate conclusions. Additional research should focus on understanding challenges specific to women in these high-risk groups. Searching for and implementing effective solutions to low breastfeeding rates beyond 4 to 6 months postpartum in high-risk women–infant dyads targets an especially vulnerable population and has the potential to make a large

impact on pediatric care and public health.

## CONCLUSIONS

Children at the highest risk for rising weight gain patterns in infancy appear to benefit the most from longer breastfeeding duration. This study contributes an obesity index screening tool that may aid in the identification of infants at high risk for obesity. Furthermore, targeting mothers of high-risk infants for breastfeeding promotion and support

may prove protective against overweight and obesity during a critical window of development when such efforts are most effective.

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## REFERENCES

1. Hanson LA. Session 1: feeding and infant development breast-feeding and immune function. *Proc Nutr Soc.* 2007;66(3):384–396. doi:10.1017/S0029665107005654
2. Leung AKC, Sauve RS. Breast is best for babies. *J Natl Med Assoc.* 2005;97(7):1010–1019
3. Tharner A, Luijk MP, Raat H, et al. Breastfeeding and its relation to maternal sensitivity and infant attachment. *J Dev Behav Pediatr.* 2012;33(5):396–404. doi:10.1097/DBP.0b013e318257fac3
4. Casazza K, Pate R, Allison DB. Myths, presumptions, and facts about obesity. *N Engl J Med.* 2013;368(23):2236–2237. doi:10.1056/NEJMc1303009
5. World Health Organization. *Evidence of the Long-Term Effects of Breastfeeding: Systematic Reviews and Meta-Analyses.* Geneva, Switzerland: WHO Press; 2007
6. Baird J, Fisher D, Lucas P, Kleijnen J, Roberts H, Law C. Being big or growing fast: systematic review of size and growth in infancy and later obesity. *BMJ.* 2005;331(7522):929. doi:10.1136/bmj.38586.411273.E0
7. Stettler N, Zemel BS, Kumanyika S, Stallings VA. Infant weight gain and childhood overweight status in a multicenter, cohort study. *Pediatrics.* 2002;109(2):194–199
8. Taveras EM, Rifas-Shiman SL, Belfort MB, Kleinman KP, Oken E, Gillman MW. Weight status in the first 6 months of life and obesity at 3 years of age. *Pediatrics.* 2009;123(4):1177–1183. doi:10.1542/peds.2008-1149
9. Hoppe C, Udam TR, Lauritzen L, Mølgaard C, Juul A, Michaelsen KF. Animal protein intake, serum insulin-like growth factor I, and growth in healthy 2.5-y-old Danish children. *Am J Clin Nutr.* 2004;80(2):447–452
10. Karlberg J, Jalil F, Lam B, Low L, Yeung CY. Linear growth retardation in relation to the three phases of growth. *Eur J Clin Nutr.* 1994;48(suppl 1):S25–S43, discussion S43–S44
11. Koletzko B. Long-term consequences of early feeding on later obesity risk. *Nestle Nutr Workshop Ser Pediatr Program.* 2006;58:1–18
12. van Rossem L, Oenema A, Steegers EA, et al. Are starting and continuing breastfeeding related to educational background? The Generation R study. *Pediatrics.* 2009;123(6). Available at: [www.pediatrics.org/cgi/content/full/123/6/e1017](http://www.pediatrics.org/cgi/content/full/123/6/e1017)
13. Appleyard K, Egeland B, van Dulmen MH, Sroufe LA. When more is not better: the role of cumulative risk in child behavior outcomes. *J Child Psychol Psychiatry.* 2005;46(3):235–245
14. Rutter M. Protective factors in children's responses to stress and disadvantage. In: Kent MW, Rolf JE, eds. *Primary Prevention of Psychopathology.* Vol. 3. Hanover, NH: University of New England Press; 1979:49–74
15. Sameroff AJ. Dialectical processes in developmental psychopathology. 2nd ed. In: Sameroff AJ, Lewis M, Miller S, eds. *Handbook of Developmental Psychopathology.* New York, NY: Kluwer Academic/Plenum Publishers; 2000:23–40
16. Olson CM, Strawderman MS. Modifiable behavioral factors in a biopsychosocial model predict inadequate and excessive gestational weight gain. *J Am Diet Assoc.* 2003;103(1):48–54. doi:10.1053/jada.2003.50001

17. Kendall A, Olson CM, Frongillo EA Jr. Evaluation of psychosocial measures for understanding weight-related behaviors in pregnant women. *Ann Behav Med.* 2001;23(1):50–58
18. Olson CM, Strawderman MS, Hinton PS, Pearson TA. Gestational weight gain and postpartum behaviors associated with weight change from early pregnancy to 1 y postpartum. *Int J Obes Relat Metab Disord.* 2003;27(1):117–127
19. World Health Organization. WHO child growth standards: methods and development. Available at: [www.who.int/childgrowth/publications/technical\\_report\\_velocity/en/index.html](http://www.who.int/childgrowth/publications/technical_report_velocity/en/index.html). Accessed June 18, 2012
20. Olson CM, Strawderman MS, Dennison BA. Maternal weight gain during pregnancy and child weight at age 3 years. *Matern Child Health J.* 2009;13(6):839–846. doi:10.1007/s10995-008-0413-6
21. Whitaker RC. Predicting preschooler obesity at birth: the role of maternal obesity in early pregnancy. *Pediatrics.* 2004;114(1). Available at: [www.pediatrics.org/cgi/content/full/114/1/e29](http://www.pediatrics.org/cgi/content/full/114/1/e29)
22. Salsberry PJ, Reagan PB. Dynamics of early childhood overweight. *Pediatrics.* 2005;116(6):1329–1338. doi:10.1542/peds.2004
23. Oken E, Taveras EM, Kleinman KP, Rich-Edwards JW, Gillman MW. Gestational weight gain and child adiposity at age 3 years. *Am J Obstet Gynecol.* 2007;196(322):e1–e8
24. Moreira P, Padez C, Mourã o-Carvalho I, Rosado V. Maternal weight gain during pregnancy and overweight in Portuguese children. *Int J Obes.* 2007;31:608–614. doi:10.1038/sj.ijo.0803582
25. Sharma AJ, Cogswell ME, Grummer-Strawn LM. The association between pregnancy weight gain and childhood overweight is modified by mother's pre-pregnancy BMI [abstract]. *Pediatr Res.* 2005;58:1038. doi:10.1203/00006450-200510000-00042
26. Goodman E, Adler NE, Daniels SR, Morrison JA, Slap GB, Dolan LM. Impact of objective and subjective social status on obesity in a biracial cohort of adolescents. *Obes Res.* 2003;11(8):1018–1026
27. Goodman E, Slap GB, Huang B. The public health impact of socioeconomic status on adolescent depression and obesity. *Am J Public Health.* 2003;93(11):1844–1850
28. Huang JS, Lee TA, Lu MC. Prenatal programming of childhood overweight and obesity. *Matern Child Health J.* 2007;11(5):461–473. doi:10.1007/s10995-006-0141-8
29. Oken E, Levitan EB, Gillman MW. Maternal smoking during pregnancy and child overweight: systematic review and meta-analysis. *Int J Obes (Lond).* 2008;32(2):201–210. doi:10.1038/sj.ijo.0803760
30. Leary SD, Smith GD, Rogers IS, Reilly JJ, Wells JCK, Ness AR. Smoking during pregnancy and offspring fat and lean mass in childhood. *Obesity (Silver Spring).* 2006;14(12):2284–2293. doi:10.1038/oby.2006.268
31. Gerald LB, Anderson A, Johnson GD, Hoff C, Trimm RF. Social class, social support and obesity risk in children. *Child Care Health Dev.* 1994;20(3):145–163
32. Alaimo K, Olson CM, Frongillo EA Jr. Low family income and food insufficiency in relation to overweight in US children: is there a paradox? *Arch Pediatr Adolesc Med.* 2001;155(10):1161–1167
33. Metallinos-Katsaras E, Must A, Gorman K. A longitudinal study of food insecurity on obesity in preschool children. *J Acad Nutr Diet.* 2012;112(12):1949–1958. doi:10.1016/j.jand.2012.08.031
34. Gundersen C, Lohman BJ, Garasky S, Stewart S, Eisenmann J. Food security, maternal stressors, and overweight among low-income US children: results from the National Health and Nutrition Examination Survey (1999–2002). *Pediatrics.* 2008;122(3). Available at: [www.pediatrics.org/cgi/content/full/122/3/e529](http://www.pediatrics.org/cgi/content/full/122/3/e529)
35. World Health Organization. Physical Status: The Use and Interpretation of Anthropometry. WHO Technical Report Series. Geneva, Switzerland: World Health Organization; 1995.
36. Rasmussen KM, Yaktine AL; Committee to Reexamine IOM Pregnancy Weight Guidelines, Food and Nutrition Board, Board on Children, Youth and Families, Institute of Medicine, Division of Behavioral and Social Sciences and Education, National Research Council. *Weight Gain During Pregnancy: Reexamining the Guidelines.* Washington, DC: The National Academies Press; 2009
37. Olson CM, Strawderman MS. The relationship between food insecurity and obesity in rural childbearing women. *J Rural Health.* 2008;24(1):60–66. doi:10.1111/j.1748-0361.2008.00138.x
38. Jones BL, Nagin DS, Roeder K. A SAS procedure based on mixture models for estimating developmental trajectories. *Sociol Methods Res.* 2001;29(3):374–393. doi:10.1177/0049124101029003005
39. Nagin DS. Analyzing developmental trajectories: a semiparametric, group-based approach. *Psychol Methods.* 1999;4(2):139–157
40. Nagin DS. *Group-Based Modeling of Development.* Cambridge, England: Harvard University Press; 2005
41. Nagin DS, Odgers CL. Group-based trajectory modeling in clinical research. *Annu Rev Clin Psychol.* 2010;6:109–138
42. Van Den Berg G, Van Eijsden M, Galindo-Garre F, Vrijkotte T, Gemke R. Low maternal education is associated with increased growth velocity in the first year of life and in early childhood: the ABCD study. *Eur J Pediatr.* 2013;172(11):1451–1457. doi:10.1007/s00431-013-2063-y
43. Wijlaars LP, Johnson L, van Jaarsveld CH, Wardle J. Socioeconomic status and weight gain in early infancy. *Int J Obes (Lond).* 2011;35(7):963–970. doi:10.1038/ijo.2011.88
44. Deierlein AL, Siega-Riz AM, Adair LS, Herring AH. Effects of pre-pregnancy body mass index and gestational weight gain on infant anthropometric outcomes. *J Pediatr.* 2011;158(2):221–226. doi:10.1016/j.jpeds.2010.08.008
45. Oyama M, Nakamura K, Tsuchiya Y, Yamamoto M. Unhealthy maternal lifestyle leads to rapid infant weight gain: prevention of future chronic diseases. *Tohoku J Exp Med.* 2009;217(1):67–72
46. Ehrenthal DB, Maiden K, Rao A, et al. Independent relation of maternal prenatal factors to early childhood obesity in the offspring. *Obstet Gynecol.* 2013;121(1):115–121. doi:http://10.1097/AOG.0b013e318278f56a
47. Butte NF, Wong WW, Hopkinson JM, Smith EO, Ellis KJ. Infant feeding mode affects early growth and body composition. *Pediatrics.* 2000;106(6):1355–1366
48. Dewey KG, Heinig MJ, Nommsen LA, Peerson JM, Lönnerdal B. Growth of breast-fed and formula-fed infants from



- 0 to 18 months: the DARLING Study. *Pediatrics*. 1992;89(6 Pt 1):1035–1041
49. de Onis M, Garza C, Onyango AW, Borghi E. Comparison of the WHO child growth standards and the CDC 2000 growth charts. *J Nutr*. 2007;137(1):144–148
50. Victora CG, Morris SS, Barros FC, de Onis M, Yip R. The NCHS reference and the growth of breast- and bottle-fed infants. *J Nutr*. 1998;128(7):1134–1138
51. Mhrshahi S, Battistutta D, Magarey A, Daniels LA. Determinants of rapid weight gain during infancy: baseline results from the NOURISH randomised controlled trial. *BMC Pediatr*. 2011;11:99. doi:10.1186/1471-2431-11-99
52. Centers for Disease Control and Prevention National Immunization Survey (NIS). Provisional data, 2010 births. Available at: [www.cdc.gov/BREASTFEEDING/DATA/NIS\\_data/](http://www.cdc.gov/BREASTFEEDING/DATA/NIS_data/)
53. Kramer MS, Guo T, Platt RW, et al. Infant growth and health outcomes associated with 3 compared with 6 mo of exclusive breastfeeding. *Am J Clin Nutr*. 2003;78(2):291–295
54. Huh SY, Rifas-Shiman SL, Taveras EM, Oken E, Gillman MW. Timing of solid food introduction and risk of obesity in preschool-aged children. *Pediatrics*. 2011;127(3). Available at: [www.pediatrics.org/cgi/content/full/127/3/e544](http://www.pediatrics.org/cgi/content/full/127/3/e544)
55. Griffiths LJ, Smeeth L, Hawkins SS, Cole TJ, Dezateux C. Effects of infant feeding practice on weight gain from birth to 3 years. *Arch Dis Child*. 2009;94(8):577–582. doi:10.1136/adc.2008.137554
56. Ulijaszek SJ, Johnston FE, Preece MA. *The Cambridge Encyclopedia of Human Growth and Development*. Cambridge, UK: Cambridge University Press; 1998

**MORE THAN MEETS THE EYE:** *I was recently at dinner with two female friends, both of whom were younger than me. One was single, while the other had recently started dating someone she met online. We were discussing the trials and tribulations of meeting someone. Given that they were intelligent, attractive, and successful women I would have guessed that this would have been reasonably easy. I was wrong. Both had turned to online dating sites and completed long forms on several of them, but had not had much success. More recently, one had tried a new site in which only photos are posted. No other information is posted or solicited by the site. She could quickly scan dozens of pictures of men. If she saw someone that interested her, she could tap on the photo. If he tapped her photo, they would be connected and could meet.*

*It seemed a bit odd to me, but as reported in The New York Times (Fashion: October 30, 2014), it is far more complicated than just tapping on the most handsome or prettiest face. The pictures tell the viewer a great deal of physical and social information. To prove the point, my companion logged into the site and we reviewed photographs together. The first photograph was of a man at a bar surrounded by friends and looking more than a bit groggy. The second was of a man with another woman. The third was a formal picture of a man with a dog. The fourth was of a causal snapshot of a smiling man in a polo shirt apparently on the beach. As we discussed the photographs, it became apparent that told us a great deal about the man. All were conveying remarkably different images (although none of us could quite understand why a man would post a picture of himself with another woman). Social scientists report this is what happens in real life. When we meet someone in a social situation, we do not have a dossier reporting whether they like moonlight walks on the beach.*

*As for my dining companions, the one who met online reported that she had liked the naturalness of the posted photograph and they had hit it off quite well when they met in person. I am so happy for her.*

Noted by WVR, MD

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