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Breastfeeding in infancy is associated with body mass index in adolescence: A retrospective cohort study comparing American Indians/Alaska Natives and non-Hispanic Whites

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Abstract

Background—American Indians and Alaska Natives (AI/ANs) have the highest obesity prevalence in the United States, but the influence of early childhood variables on body mass index (BMI) is not well understood. Previous studies have investigated the association between breastfeeding in infancy and offspring BMI, but rarely included AI/ANs.

Objective—This study investigated the association between breastfeeding in infancy and BMI in AI/AN and non-Hispanic White (NHW) adolescents and young adults.

Design—Longitudinal analysis based on data from the National Longitudinal Study of Adolescent to Adult Health (1994–2008).

Participants—Adolescent respondents who self-identified as AI/AN or NHW, reported their height and weight, and whose parents completed the parental questionnaire. The final sample included 655 AI/AN and 10,305 NHW respondents.

Statistical analyses performed—Generalized estimating equations were used to measure the mean differences, 95% confidence intervals, and p-values of the association between breastfeeding in infancy and offspring BMI in adolescence, stratifying by race, and adjusting for demographic and socioeconomic variables.

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CONFLICT OF INTEREST DISCLOSURE

All authors declare that they have no conflict of interest.

Results—The length of breastfeeding was inversely associated with BMI in both populations. AI/ANs that were breastfed 6 to 12 months or more than 12 months had an average BMI 2.69 (95% CI −3.46, −1.92; $p<0.01$) and 1.54 (95% CI −2.75, −0.33; $p<0.05$) units lower than those that were never breastfed. NHWs that breastfed for 3 to 6 months, 6 to 12 months, or more than 12 months had a mean BMI 0.71 (95% CI −0.93, −0.50; $p<0.01$), 0.68 (95% CI −0.87, −0.50; $p<0.01$), and 0.85 (95% CI −1.09, −0.62; $p<0.01$) units lower than those that were never breastfed. The association between the length of breastfeeding and offspring BMI varied by race ($p<0.01$).

Conclusion—Breastfeeding in infancy is associated with a lower mean BMI. Future research should investigate causal pathways and whether interventions promoting breastfeeding in AI/ANs can prevent increasing BMI.

Keywords

American Indian/Alaska Native; breastfeeding; body mass index; National Longitudinal Study of Adolescent to Adult Health; health disparities

BACKGROUND

Seventy-one percent of American Indians and Alaska Natives (AI/ANs) aged 18 and older are either overweight or obese, compared to 59% of non-Hispanic Whites (NHWs) in the same age range.¹ Extreme obesity, defined as a body mass index (BMI) 120% higher than the 95th percentile,² is declining in all racial and ethnic groups in the United States (US) except AI/ANs.³ Overweight and obesity in AI/ANs are associated with multiple comorbidities and early mortality,⁴ but interventions to reduce obesity in AI/AN youth have been unsuccessful.^{5,6} Previous studies have shown that diet and exercise are key lifestyle behaviors linked with obesity in AI/AN youth,^{7–12} but few studies have analyzed the role of the postnatal environment in general^{13–15} or breastfeeding in particular.¹⁶ Consequently, examining the role of breastfeeding in AI/ANs as compared to NHWs can inform the study of BMI and its disparities.

Reviews of the literature on breastfeeding and BMI in NHWs have returned mixed findings.^{17–20} A recent meta-analysis reported that the variability of these findings could be a product of research design, breastfeeding categories, and mean age at BMI assessment.²¹ Although AI/ANs have the highest prevalence of obesity in the US, only one study has estimated the effect of breastfeeding on the BMI of AI/AN children.¹⁶ Evidence from three tribes in Wisconsin showed that children aged 5–8 years who had been breastfed for at least 4 months were less likely to become overweight or obese than their counterparts who were breastfed for a shorter period or not at all.¹⁶ Two other studies offered insights on breastfeeding in AI/AN communities, even though they did not measure the relationship between breastfeeding and BMI. One examined new AI/AN mothers' knowledge, attitudes, and beliefs regarding breastfeeding, finding that mothers were aware of prevailing recommendations for breastfeeding but not of the associated health benefits.¹⁴ The other demonstrated the feasibility of an intervention aimed at increasing breastfeeding rates among AI/ANs, but did not examine the effect of breastfeeding on infants' BMI.¹⁵

No published study of AI/ANs has measured the relationship between the length of breastfeeding in infancy and offspring BMI in adolescence or early adulthood. Moreover, no study to date has examined the potential role of breastfeeding in the BMI disparity between AI/ANs and NHWs. The National Longitudinal Study of Adolescent to Adult Health (Add Health) has the largest cohort of AI/AN adolescents and young adults ever recruited for a research study. This study used Add Health data to conduct the first analysis of the association between the length of breastfeeding in infancy and BMI in adolescence and early adulthood in AI/ANs. Given the lack of prior research in this population and the mixed findings of previous studies, this study did not assume the existence, direction, and magnitude of this association. The objectives of the present study were to measure the association between the length of breastfeeding in infancy and offspring BMI in AI/ANs and NHWs aged 11–34 years; determine whether this association persisted even after adjusting for socioeconomic status; and determine if this association was similar for AI/ANs and NHWs.

METHODS

Study sample

Add Health is a survey conducted by the Carolina Population Center at the University of North Carolina-Chapel Hill with a nationally-representative sample of adolescents and young adults. Respondents were recruited from public schools across the country and followed for four waves of data collection in 1994, 1996, 2002, and 2008. Schools were eligible to participate if they had a minimum enrollment of 30 students and offered classes at the 11th grade level. Add Health conducted in-home questionnaires with all respondents from the school sample. All respondents were 11–20 years old at baseline (Wave 1). Full details of the research design and the data collection process have been previously published.²² The present study was deemed exempt by the University of Washington Institutional Review Board.

Wave 1 administered separate questionnaires to 20,745 adolescents and 17,669 of their parents. Both mothers and fathers were allowed to complete the parental questionnaire. If both parents were available, Add Health asked mothers to complete the questionnaire. Thus, more than 90% of the parental questionnaires were completed by mothers. None of the subsequent waves included a parental questionnaire. The analyses were limited to respondents who self-identified as AI/AN or NHW and reported their height and weight, and whose parents completed the parental questionnaire. Add Health recruited respondents from singletons and multiple births, and when twin siblings were identified, they were recruited. This study excluded twin siblings, to treat all participants as independent respondents. Respondents who self-identified as African American, Asian, Hispanic/Latino, and Pacific Islander were excluded, as well as those whose parents did not complete the questionnaire. The resulting sample included 655 AI/AN and 10,305 NHW respondents.

Variables

Outcome—The dependent variable for all models was repeated measures of BMI (waves 1–4), coded as a continuous variable. BMI was measured by using self-reported height and

weight. Epidemiologic data from the Centers for Disease Control and Prevention were used to estimate the percentage of respondents above the 85th and 95th percentiles for BMI at Wave 1.²³

Exposure—Length of breastfeeding was measured in Wave 1 by asking parents, “For how long was [name of adolescent] breastfed?” Parents could respond: a) never, b) less than 3 months, c) 3 months to less than 6 months, d) 6 months to less than 9 months, e) 9 months to less than 12 months, f) 12 months to less than 24 months, or g) 24 months or more. Response categories were collapsed into the categories of the American Academy of Pediatrics: never, less than 3 months, 3 to 6 months, 6 to 12 months, or more than 12 months.²⁴

Covariates—The adolescent questionnaire provided data to adjust for age and sex and stratify by race (AI/AN, NHW). The parental questionnaire provided data to adjust for adolescents’ birth weight and socioeconomic status, using three proxies: a) parental education (less than high school, high school graduate, college graduate), b) financial instability (reported inability to pay bills), and c) parental employment (employed, unemployed). A fourth variable designating household income was also available, but a large number of adult respondents declined to report their income. Given the possibility that missing values might not be missing at random, this variable was not included in the models.

Statistical analysis

All analyses were conducted by using the R statistics package.²⁵ A complete case analysis was conducted by using unique identifiers to track anonymized data on individual respondents over all four waves of Add Health. Length of breastfeeding was the primary exposure of interest. Generalized estimating equations were used to model the association between the length of breastfeeding in infancy and offspring BMI in adolescence, stratifying by race and adjusting for demographic and socioeconomic covariates.

Before testing any hypothesis, patterns in respondent attrition were estimated. The Add Health research team examined non-responses between Waves 1 and 4, concluding that obesity did not predict non-response.²⁶ Logistic regression models and receiver operating characteristic curves were used to determine whether specific variables predicted attrition. Bootstrapping was used to obtain standard errors for areas under the curve. As all areas under the curve were less than 0.60 (a very weak predictor), missing values were determined to be missing completely at random (data not shown).

Means, standard deviations, proportions and p-values were used to characterize the study sample. The first model estimated whether the length of breastfeeding in infancy was associated with offspring BMI, adjusting for age and birth weight, and stratifying results by race. Cubic splines with two knots at 15 and 18 years were used to control for age and model the non-linear relationship between age and BMI, like previous studies have done.^{27,28}

The second model added three proxies for socioeconomic status in order to assess its role in the association between the length of breastfeeding in infancy and offspring BMI. These proxies were parental education, financial instability, and parental employment. Further tests

were used to determine whether the association between length of breastfeeding in infancy and offspring BMI varied between the two races. Results are presented with mean differences, 95% confidence intervals (CI) and p-values. P-values below 0.05 were considered statistically significant.

Finally, sensitivity analyses were conducted to assess the robustness of results. Models were re-run with breastfeeding as a binary exposure (any breastfeeding versus none at all). All these models led to similar findings about the association between the length of breastfeeding in infancy and offspring BMI in AI/AN and NHW adolescents and young adults.

RESULTS

Table 1 shows that retention rates over all waves of Add Health ranged from 71% to 79%, similar to rates in the National Health and Nutrition Examination Survey²⁹ and higher than other longitudinal surveys with a 10-year follow-up.³⁰ Table 2 provides descriptive statistics of the two population samples. In Wave 1, AI/ANs and NHWs had an average age of 16 years and similar distributions by sex and birth weight. AI/ANs had an average BMI of 23 (standard deviation [SD] 5); 30% were overweight and 15% were obese. NHWs had an average BMI of 22 (SD 4); 22% were overweight and 9% were obese. Thus, already in adolescence, obesity was more prevalent in AI/ANs than in NHWs. The two samples exhibited differences in socioeconomic status as well. Compared to their NHW counterparts, lower percentages of AI/AN parents graduated from high school (78% vs. 90%), were employed (66% vs. 75%) and higher percentages were financially unstable (22% vs. 13%). In both groups, most participants (52% of NHWs, 56% of AI/ANs) had never been breastfed (Table 2). Among those with any history of breastfeeding, 15% of NHWs and 16% of AI/ANs were breastfed for less than 3 months, and only 8% of NHWs and 7% of AI/ANs were breastfed for more than 12 months.

Table 3 summarizes the association between the length of breastfeeding in infancy and offspring BMI, adjusting for sex and birth weight, and further adjusting for socioeconomic status. Adjusting for sex and birth weight, breastfeeding in infancy was associated with a mean difference in adolescent BMI. AI/AN adolescents that were breastfed 6 to 12 months, or more than 12 months, had an average BMI 2.87 (95% CI -3.60, -2.14; $p < 0.01$) and 2.30 (95% CI -3.48, -1.13; $p < 0.01$) units lower than those that were never breastfed. NHW adolescents that were breastfed for 3 to 6 months, 6 to 12 months, or more than 12 months had an average BMI 0.89 (95% CI -1.10, -0.68; $p < 0.01$), 0.93 (95% CI -1.10, -0.75; $p < 0.01$), and 1.09 (95% CI -1.31, -0.86; $p < 0.01$) units lower than those that were never breastfed, respectively.

After additional adjustment for parental education, financial instability, and parental employment, the length of breastfeeding in infancy was still associated with a negative mean difference in offspring BMI. AI/AN adolescents that were breastfed 6 to 12 months or more than 12 months had an average BMI 2.69 (95% CI -3.46, 1.92; $p < 0.01$) and 1.54 (95% CI -2.75, -0.33; $p < 0.05$) units lower than those that were never breastfed, respectively. In NHWs, breastfeeding durations of 3 to 6 months, 6 to 12 months, or more than 12 months

were respectively associated with an adolescent BMI 0.71 (95% CI -0.93, -0.50; $p<0.01$), 0.68 (95% CI -0.87, -0.50; $p<0.01$), and 0.85 (95% CI -1.09, -0.62; $p<0.01$) units lower than those that never breastfed.

Further tests were used to determine whether the association between the length of breastfeeding in infancy and offspring BMI varied by race. Results showed that this association was stronger for AI/ANs than for NHWs ($p<0.01$) (data not shown). Figure 1 illustrated the association between the length of breastfeeding in infancy and mean difference in BMI for each racial group, adjusting for respondent's sex, birth weight, parental education, parental employment and parental financial stability. Increasing the length of breastfeeding in infancy was associated with a higher mean difference in BMI for AI/ANs than for NHWs, on average.

DISCUSSION

For decades, physicians, midwives, and new mothers have pondered the extent to which formula can substitute for breast milk.³¹ The American Association of Pediatrics³² and the World Health Organization³³ recommend six months of exclusive breastfeeding and one to two years of complementary breastfeeding (i.e., breastfeeding along with solid food). Increasing breastfeeding rates is a top priority for the US Surgeon General and for Healthy People 2020, which seeks to raise breastfeeding initiation rates from 74% to 82%, breastfeeding at six months from 44% to 61%, and breastfeeding at one year from 23% to 34%.^{34,35}

This analysis offers the first longitudinal examination of the association between the length of breastfeeding in infancy and offspring BMI in AI/AN adolescents. Longer breastfeeding in infancy was associated with a negative mean difference in offspring BMI. Adolescents that had been breastfed for 6 to 12 months or 12 months or more had a lower BMI, on average, than those who had not been breastfed. Evidence of the inverse association between the length of breastfeeding in infancy and increasing BMI is consistent with previous findings that breastfeeding is inversely associated with excess weight gain in AI/ANs¹⁶ and other racial and ethnic groups.^{17,19}

Previous research on breastfeeding and cardiometabolic indicators has returned mixed results. Two reviews concluded that breastfeeding protects against obesity,^{18,36} but two others argued that the evidence supporting this conclusion was insufficient.^{17,19} The lack of agreement might stem from variations in research methods. Some studies have approached breastfeeding in terms of its nutritional role – e.g., exclusive breastfeeding^{37,38} versus predominant breastfeeding^{39,40} – while others have examined the age when solid foods are incorporated into children's diets.^{41,42} Studies also differ in their classification of breastfeeding groups and developmental stages,^{16,20,43} as well as in their population samples. Some have analyzed nationally representative samples,^{44–46} while others have focused on subgroups, such as low-income women^{47,48} adolescent mothers,^{49,50} and mothers of specific racial, ethnic, or immigrant origin.^{51,52} Some studies have adjusted for socioeconomic status, others have not.²¹ The present analysis is consistent with previous findings that breastfeeding in infancy is associated with lower BMI in adolescence.

Further research is needed to examine the potential causal pathways between breastfeeding in infancy and offspring BMI. A recent literature review argued that this association might be a product of biological, behavioral, or psychological factors in breastfed infants, or indeed that it might be a spurious association due to confounding factors.⁵³ The present analysis contributes to this literature by showing that the association between the length of breastfeeding in infancy and offspring BMI is present in both AI/ANs and NHWs, and appears to be stronger in AI/ANs. Nevertheless, these populations are likely to exhibit substantial cultural differences that Add Health was not designed to capture. Research that examines how the unique cultural environments of AI/AN populations contribute to health outcomes such as obesity may provide valuable insights that would eventually lead to more effective health interventions.^{54,55} The results of such work are likely to inspire more robust theoretical models of obesogenesis, as well as more effective health interventions for its prevention.

This study has limitations that should be taken into consideration. First, data to calculate the primary outcome, adolescent BMI, relied on self-reported height and weight. This is problematic because previous studies have shown that overweight adolescents tend to underreport their weight.⁵⁶ Second, given the nature of the data, this study could not determine a causal path between the length of breastfeeding in infancy and offspring BMI in adolescence. Third, with regard to the length of breastfeeding, Add Health did not distinguish between exclusive, predominant, or complementary modes, and did not indicate whether babies were fed breast milk from the breast or breast milk from a bottle. Recent studies suggest that different feeding methods could differentially affect appetite regulation.⁵⁷ Fourth, Add Health data on breastfeeding might be subject to recall bias.⁵⁸ This variable was collected during Wave 1, when adolescent respondents were 11–20 years old. Given the substantial lapse of time between birth and survey response, mothers who breastfed for a short time might have reported an inaccurate length of breastfeeding. Fifth, AI/ANs and NHWs were examined as homogeneous populations, even though both groups are extremely heterogeneous.⁵⁹ Of note, Add Health did not collect data on tribal affiliation among participants who self-identified as AI/AN. Future studies are encouraged to solicit tribal affiliation from AI/AN respondents. Sixth, data on parental education, financial instability, and parental employment were collected during Wave 1, but not at the time of the exposure or in any subsequent waves. Therefore, this study could not assess these variables when adolescent respondents were breastfed, how these variables might have changed over time, and how such changes might have affected offspring BMI in adolescence. Seventh, Add Health did not collect parental height and weight or health consciousness, so the effects of parental BMI and health consciousness could not be estimated. Finally, Add Health did not oversample AI/ANs, even though it has the largest cohort of AI/AN adolescents and young adults ever recruited for a research study. Nevertheless, these results offer generalizable findings about disparities between AI/AN and NHW youth. National surveillance efforts are needed to oversample minority populations and enable analyses of within-group variability on all covariates of interest. Future datasets are also needed to track breastfeeding behaviors over time, collect measures beyond the length of breastfeeding, and estimate the associations between breastfeeding and multiple physical and mental health outcomes over the life course.

CONCLUSION

This study contributes to the literature on breastfeeding, BMI, and AI/AN health, by finding that the length of breastfeeding in infancy is associated with a negative mean difference in adolescent BMI. The results showed that this association persists after adjusting for socioeconomic status, and is stronger for AI/ANs than for NHWs. Empirical tests of the causal pathways linking the length of breastfeeding in infancy with BMI in later life are needed. The present findings add incrementally to the evidence-base that supports the promotion of breastfeeding in all US populations, and especially in groups such as AI/ANs who have a disproportionately high BMI.

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Figure 1. Association^a between the length of breastfeeding in infancy and mean differences in BMI, among AI/AN^b and NHW^c respondents of the National Longitudinal Study of Adolescent to Adult Health (1994–2008)

^aResults adjusted for age, sex, birth weight, parental education, parental employment, and parental financial stability.

^bAI/AN = American Indian/Alaska Native.

^cNHW = Non-Hispanic White.

Table 1

Retention of AI/AN^a and NHW^b respondents across the four waves of the National Longitudinal Study of Adolescent to Adult Health (1994–2008)

	<u>AI/ANs</u>		<u>NHWs</u>	
	<u>n</u>	<u>%</u>	<u>N</u>	<u>%</u>
Baseline/Wave 1 ^(c)	655	100	10,305	100
Wave 2	467	71	7,380	72
Wave 3	477	73	7,715	75
Wave 4	469	72	8,135	79

^a AI/ANs = American Indians/Alaska Natives.

^b NHWs = Non-Hispanic Whites.

^c The final sample size was 655 AI/AN and 10,305 NHW.

Table 2

Descriptive characteristics of AI/AN^a and NHW^b baseline (Wave 1) respondents in the National Longitudinal Study of Adolescent to Adult Health (1994–2008)

	<u>AI/AN</u> <u>(n=655)</u>		<u>NHW</u> <u>(n=10,305)</u>	
<i>Adolescent characteristics:</i>				
Age; Mean (SD) ^{c*}	16	(2)	16	(2)
Sex; n (%)				
Male	309	(47)	5,088	(49)
Female	346	(53)	5,217	(51)
Birth weight, in ounces; Mean (SD) ^{c*}	117	(20)	120	(19)
Length of breastfeeding; η (%)				
Never	303	(56)	4,671	(52)
Less than 3 months	86	(16)	1,322	(15)
3 to 6 months	57	(11)	981	(11)
6 to 12 months	58	(11)	1,291	(14)
More than 12 months	38	(7)	690	(8)
Body mass index ^d ; Mean (SD) ^{c*}	23	(5)	22	(4)
85 th percentile; n (%) [*]	189	(30)	2,240	(22)
95 th percentile; n (%) [*]	94	(15)	857	(9)
<i>Parental characteristics:</i>				
Parental education; n (%)				
Less than high-school	127	(22)	927	(10)
High school graduate	328	(58)	5,920	(65)
College graduate	114	(20)	2,292	(25)
Financial stability; n (%) [*]				
Financial instability	126	(22)	1,180	(13)
Employment status; n (%) [*]				
Employed	379	(66)	6,898	(75)

^a AI/ANs = American Indians/Alaska Natives.

^b NHWs = Non-Hispanic Whites.

^c SD = Standard deviation.

^d Body mass index was calculated using adolescent respondents' self-reported height and weight.

^{*} p-value <0.05

Table 3

Mean differences, 95% confidence intervals, and p-values for the association between the length of breastfeeding and body mass index in AI/AN^a and NHW^b Add Health respondents (1994–2008)

	Estimates for mean BMI differences over time, adjusting for sex and birth weight				Estimates for mean BMI differences over time, adjusting for sex, birth weight, parental education, financial problems and parental employment			
	AI/ANs		NHWs		AI/ANs		NHWs	
	Mean	CI ^c	Mean	diff.	Mean	CI ^c	Mean	diff.
<i>Length of breastfeeding</i>								
Never (ref.)	ref.		ref.		ref.		ref.	
Less than 3 months	0.43	(−0.60, 1.45)	−0.23		0.78	(−0.29, 1.85)	−0.10	(−0.29, 0.10)
3 to 6 months	−0.15	(−1.40, 1.10)	−0.89		−0.25	(−1.42, 0.91)	−0.71	(−0.93, −0.50)**
6 to 12 months	−2.87	(−3.60, −2.14)**	−0.93		−2.69	(−3.46, −1.92)**	−0.68	(−0.87, −0.50)**
More than 12 months	−2.30	(−3.48, −1.13)**	−1.09		−1.54	(−2.75, −0.33)*	−0.85	(−1.09, −0.62)**
Female	−0.68	(−1.36, 0.01)	−0.52		−0.81	(−1.49, −0.12)*	−0.54	(−0.67, −0.41)**
Birth weight	0.04	(0.02, 0.05)**	0.02		0.04	(0.02, 0.07)**	0.02	(0.02, 0.02)**
<i>Parental education</i>								
Less than high school					1.61	(0.64, 2.57)*	0.69	(0.43, 0.96)**
High school graduate (ref.)					ref.		ref.	
College graduate					−0.06	(−0.95, 0.83)	−0.50	(−0.65, −0.36)**
<i>Financial problems</i>								
No (ref.)					ref.		ref.	
Yes					0.22	(−0.63, 1.08)	0.53	(0.32, 0.74)*
<i>Parental employment</i>								
Employed (ref.)					ref.		ref.	
Unemployed					−1.01	(−1.08, −0.28)*	0.16	(0.00, 0.31)**

^a AI/ANs = American Indians/Alaska Natives.

^b NHWs = Non-Hispanic Whites.

^c CI = 95% confidence interval.

10.0>P
**
50.0>P
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