

Breastfeeding Effects on Intelligence Quotient in 4- and 11-Year-Old Children

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ABSTRACT. *Objective* A study of preterm children found an IQ advantage among those who were breastfed as infants after controlling for maternal social class and educational status. However, this advantage needs to be examined in light of other maternal characteristics, such as maternal IQ and parenting skills, which were not measured in that study and which have been found to be related to breastfeeding.

Methodology. IQ was assessed in 323 children at 4 years of age on the McCarthy Scales of Children's Abilities and the Peabody Picture Vocabulary Test-Revised and in 280 children on the Wechsler Intelligence Test for Children-Revised at 11 years of age.

Results. Children who were breastfed in infancy had significantly higher scores on IQ tests at both ages, even after adjusting for social class and education, confirming the earlier findings and extending them to a predominantly full-term sample. However, the effect of breastfeeding was no longer significant after adjusting for maternal IQ assessed on the Peabody Picture Vocabulary Test-Revised and for parenting skills assessed on the Home Observation for Measurement of the Environment. Significant relations between breastfeeding and Woodcock Reading Achievement scores at 11 years were also reduced to nonsignificant levels after the inclusion of maternal IQ and the Home Observation for Measurement of the Environment.

Conclusions. These findings suggest that the observed advantage of breastfeeding on IQ is related to genetic and socioenvironmental factors rather than to the nutritional benefits of breastfeeding on neurodevelopment. They should not be interpreted as detracting from the medical benefits associated with breastfeeding. *Pediatrics* 1999;103(5). URL: <http://www.pediatrics.org/cgi/content/full/103/5/e71>; *breastfeeding, IQ, intelligence, socioeconomic status.*

ABBREVIATIONS. WISC-R, Wechsler Intelligence Scale for Children-Revised; SES, socioeconomic status; PPVT-R, Peabody Picture Vocabulary Test-Revised; PCB, polychlorinated biphenyls; PBB, polybrominated biphenyls; GCI, General Cognitive Index; HOME, Home Observation for Measurement of the Environment.

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I ncreased awareness of the nutritional and medical benefits of breastfeeding, including reduced incidence of infection and allergic reaction,¹⁻⁹ has led to its endorsement by medical and professional groups¹⁰⁻¹² and to substantial increases in the number of women choosing to breastfeed.^{13,14} A study of 300 British children showed that children who consumed breast milk in the early weeks of life also had significantly higher IQ scores at 7.5 to 8 years on an abbreviated version of the Wechsler Intelligence Scale for Children (WISC) than those who were not breastfed.¹⁵ The sample was made up of preterm infants fed breast milk or formula by tube. Although regression analyses indicated an IQ difference even after controlling for social class and the mother's education, the decision to breastfeed may reflect intellectual and other parental factors, such as parenting skills and positive health attitudes that may be responsible for the higher IQ scores.

Others have also consistently reported that breastfed children score slightly higher than those bottlefed on the Bayley Scales of Infant Development or later tests of IQ, such as the McCarthy Scales, after controlling for standard covariates including socioeconomic status (SES), maternal age and education, maternal smoking and drinking,^{16,17} and in one study maternal psychological state.¹⁸ Longitudinal studies indicate that these differences persist to 5 years and into school age. The most recent follow-up study reported associations between duration of breastfeeding and childhood cognitive ability and academic achievement extending from 8 to 18 years in a New Zealand cohort of 1000 children.¹⁹ This study found that these effects were significant after controlling for measures of social and family history, including maternal age, education, SES, marital status, smoking during pregnancy, family living conditions, and family income, and measures of perinatal factors, including gender, birth weight, child's estimated gestational age, and birth order in the family. These small observed differences in IQ and achievement have been attributed to nutritional and social determinants of breastfeeding, but none of these studies have partialled out the genetic and socioenvironmental factors related to maternal IQ from the nutritional benefits of breastfeeding.

Most studies assessing determinants of breastfeeding have focused primarily on parental demographic and attitudinal characteristics.^{15,20,21} In an earlier study, we compared cognitive and personality correlates of breastfeeding in two independent samples:

137 black inner city mothers and 50 predominantly white lower income mothers²² receiving nutritional supplemental support from Women, Infants, and Children (WIC). Although unrelated to maternal depression, stress, and social support, the decision to breastfeed and the duration of breastfeeding were related positively to maternal verbal IQ on the Peabody Picture Vocabulary Test-Revised (PPVT-R²³) and ego development (Loevinger Sentence Completion Test²⁴) in both samples. An earlier study, comparing breastfeeding and bottlefeeding mothers, found also that mothers who breastfed had higher verbal IQ scores on the PPVT-R, provided a more enriched home environment (Home Observation for Measurement of the Environment (HOME) Inventory),²⁵ and were less authoritarian.¹⁷ Similar results were reported in an earlier New Zealand study of 1037 children.²⁶

The present study examined the degree to which differences in maternal IQ and quality of intellectual stimulation may account for the reported association between breastfeeding and childhood IQ. We extend the IQ findings to 11-year IQ and achievement scores and discuss our 4- and 11-year data in light of additional findings by Lucas et al.²⁷

METHODS

Subjects

The sample is made up of 323 white, predominantly middle-class children (172 males and 151 females) at 4 years, and 280 children (148 males and 132 females) seen again at 11 years. These children are participating in a prospective longitudinal study on the effects of prenatal exposure to polychlorinated biphenyls (PCBs), a ubiquitous environmental contaminant.^{28,29} The sample was drawn from two cohorts of children evaluated at 4 and 11 years of age. At 4 years of age, the Lake Michigan cohort consisted of 236 (75.4%) of 313 children recruited in 1980 through 1981 when 8482 women delivering infants in four Western Michigan hospitals were surveyed regarding their consumption of Lake Michigan sportsfish.³⁰ All women consuming at least 11.8 kg of Lake Michigan fish over a 6-year period were invited to participate in the study. A small proportion (4.6%) of those who had not consumed these fish were also recruited and constituted 22.7% of the final sample. As a check on whether the women who were invited to participate were similar demographically to the women who were not recruited, a demographic comparison group was selected by matching each potential participant with the next woman whose screening interview followed her own. This procedure assured a comparison group matched for hospital and approximate date of delivery with the sample of exposed and nonexposed children. Participants did not differ from others in their community in social

class, maternal age and education, marital status, or gender of infant. Among the women who agreed to participate, those who were exposed and those who were not exposed also did not differ on any of these demographic characteristics. The mothers retained at the 4-year follow-up visit were somewhat higher in social class and education, more likely to be married, and slightly older when compared with mothers who did not return; there was the same ratio of boys to girls among participants and nonparticipants.³¹

The second cohort consisted of 87 children who were also born in 1980 through 1981 but who had not been assessed as infants. Their families were enrolled in long-term studies of exposure to PCB- or polybrominated biphenyl (PBB)-contaminated farm products conducted by the Michigan Department of Public Health. Details regarding recruitment and effects of the PCB exposure are published elsewhere.^{28,29,31-34} Despite different criteria for their recruitment, the two cohorts were similar in social class, demographic characteristics, perinatal risk, weeks of breastfeeding, and maternal and child PPVT-R scores and child McCarthy General Cognitive Index (GCI). Therefore, their data have been pooled in the analyses presented here and elsewhere. The two cohorts of children were assessed by the same project staff, who were not informed of their cohort membership. Although prenatal PCB exposure has been shown to relate to subtle cognitive deficits, no PCB- or PBB-related cognitive deficits have been found in relation to postnatal exposure to breast milk.^{29,32-34}

At 11 years, 271 (83.9%) of the 323 children seen at 4 years of age were evaluated again. In addition, 9 children seen in infancy but not at 4 years rejoined the cohort at age 11. The participants were similar to those lost to follow-up in terms of social class, maternal education, marital status, gender of child, and number of weeks of breastfeeding; participants were slightly older than nonparticipants (mean age = 31.2 and 29.5; $P < .05$, respectively). Informed consent was obtained from the mothers in the hospital and again at 4 and 11 years of age as well as assent from the children at 11 years.

Procedure

The dichotomous variable breastfed/nonbreastfed shown in Tables 1 and 2 was constructed by dividing the sample between those who reported breastfeeding versus those who chose not to breastfeed. Detailed data on infant feeding patterns were collected at 2, 4, 5, and 7 months from the Lake Michigan cohort, so that the infant could be classified in one of five categories ranging from exclusively breastfed to exclusively bottle-fed. Because these detailed estimates were correlated highly with the number of weeks of nursing ($r = .94$; $P < .001$), the simpler measure, weeks of nursing, was used to indicate the amount of breast milk consumed for all of the children in the study.³¹ Weeks of nursing was transformed by recoding seven values >3 SD units above the mean to 1 point greater than the highest observed value, as recommended by Winer.³⁵ This measure of breastfeeding was used in the regression analyses shown in Tables 3 and 4.

The McCarthy Scales of Children's Abilities were administered to each child in his or her home (mean age 4.1 years; SD = 0.1).³⁶ The McCarthy Scales provide standardized test scores for five domains of functioning and an overall summary score, the GCI, which is correlated highly ($r = 0.81$) with IQ assessed on the

TABLE 1. Demographic Characteristics of the Sample

Characteristics	4 Years				<i>t</i> or χ^2	11 Years				<i>t</i> or χ^2
	Not Breastfed (<i>N</i> = 85)		Breastfed (<i>N</i> = 237)			Not Breastfed (<i>N</i> = 72)		Breastfed (<i>N</i> = 207)		
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Socioeconomic status	36.2	11.0	41.0	12.7	-3.1**	39.2	10.4	42.7	11.3	-2.3*
Maternal age	26.2	5.3	26.9	4.4	-1.2	26.3	5.5	26.9	4.4	-0.9
Education (y)	12.8	1.9	13.6	2.0	-3.2***	12.9	1.6	14.0	2.0	-4.2****
Verbal IQ (PPVT-R)	92.9	15.1	100.3	14.5	-4.0****	93.3	15.0	101.3	14.1	-4.1****
HOME score	46.2	4.4	48.3	4.1	-3.9****	46.4	4.4	48.5	4.0	-3.8****
Birth weight (g)	3490.6	542.1	3612.8	525.1	-1.6	3506.4	464.0	3637.8	524.6	-1.6
Gestational age at birth (wk)	39.9	2.3	40.1	1.8	-0.8	40.2	1.9	40.1	1.8	0.2
Parity	2.2	1.5	2.0	1.0	1.4	2.3	1.6	2.0	1.0	1.8
Sex of infant (% males)	52.9		53.2		0.0	51.4		53.1		0.0

Values are means (SD) except for sex of infant.

* $P < .05$; ** $P < .005$; *** $P < .001$; **** $P < .0001$.

TABLE 2. IQ at 4 and 11 Years by Breastfeeding Group

	Mean (SD)		<i>t</i>
	Not Breastfed	Breastfed	
4 year			
McCarthy GCI	100.9 (14.0)	105.3 (14.5)	-2.45*
PPVT-R (child)	98.0 (15.2)	104.4 (13.6)	-3.62***
11 year			
WISC-R			
Verbal IQ	102.9 (13.1)	107.8 (13.5)	-2.70**
Performance IQ	104.1 (11.9)	107.7 (13.3)	-2.06*
Full scale IQ	103.7 (12.0)	108.5 (12.9)	-2.77**

* $P < .05$; ** $P < .01$; *** $P < .0001$.

Stanford-Binet test.³⁶ Interobserver reliability for the items in the McCarthy Scales requiring discretionary judgment ranged from 94% to 100% (median = 99%). There were no significant differences among the examiners in the scores obtained by the children they tested ($P > .15$ in all cases). The McCarthy Scales were supplemented by the PPVT-R, a brief vocabulary recognition test, that is correlated strongly with the WISC Vocabulary subtest (median $r = .69$; the WISC Verbal Scale, median $r = .66$; and the Full Scale WISC, median $r = .64$).²³

Each child was tested again individually at home at a mean age of 11.0 (SD = 0.2) on the WISC-R,³⁷ the spelling and arithmetic subtests of the Wide Range Achievement Test-Revised,³⁸ and the word and passage comprehension subtests of the Woodcock Reading Mastery Tests-Revised.³⁹ Reading comprehension was computed as the average of the scores for word and passage comprehension. None of the examiners were aware of the children's breastfeeding history. The interexaminer reliability in recording the children's response times (r) ranged from 0.98 to 1.00.

The mother was interviewed in an adjacent room by a second examiner at the 4- and 11-year visits. SES was assessed using the Hollingshead Four Factor Index⁴⁰ that is based on the occupational status and educational attainment of both parents and that has proven to be related more strongly to early childhood cognitive functioning (median $r = .40$) than other standard indices of SES.⁴¹ Maternal verbal IQ was assessed on the PPVT-R, which is related strongly with more comprehensive measures of adult IQ, such as the Wechsler Adult Intelligence Scale (median $r = .72$) and is highly stable (median $r = .72$).²³ PPVT-R data are missing for one mother, a social worker who was familiar with the test. Quality of parenting was evaluated at 4 years on the preschool version of the HOME²⁵ that combines a semistructured maternal interview with observation of mother-child interaction. The validity and sensitivity of the HOME as an indicator of socioenvironmental influences on development have been demonstrated by evidence that it explains significant variance in childhood cognitive function over and above that attributable to SES and maternal education.^{42,43} Median interobserver reliability for the HOME was 96% (range = 84% to 100%). The elementary HOME, designed for children from 6- to 10-years old, was not given at the 11-year visit, because it was not considered valid for this age group and because we have found that version to be more valid at the younger end of the age range.

Data Analysis

Statistical analyses used were the Student's t test, Pearson correlation, χ^2 test, and multiple regression.

RESULTS

Demographic and other characteristics of the mothers and children, broken down by breastfeeding choice, are presented in Table 1. Almost three-fourths (4 years: 73.4%; 11 years: 73.8%) of the mothers breastfed their infants for an average of ~6.5 months (4 years: mean = 28.1 weeks, SD = 27.7; 11 years: mean = 28.7 weeks, SD 28.4). Of the 237 women at the 4-year follow-up who had breastfed their infants, 97 (40.9%) breastfed <4 months; 32 (13.5%) 4 to 5.9 months; 68 (28.7%), 6 to 11.9 months;

and 40 (16.9%) ≥ 1 year. Of the 207 women at the 11-year visit who had breastfed, comparable proportions of the mothers breastfed for the same number of months: 81 (39.1%) breastfed <4 months; 30 (14.5%) for 4 to 5.9 months; 60 (29.0%) for 6 to 11.9 months; and 36 (17.4%) ≥ 1 year.

Breastfeeding was related to higher social class and education at both ages, confirming earlier studies.^{13-15,20,21,26} Mothers who breastfed also scored higher on the PPVT-R and had more optimal parenting skills assessed on the HOME. Distributions in the two groups were similar for maternal age, gestational age, and gender of child at 4 and 11 years. Only one infant who was not breastfed weighed <2000 g at birth (1818 g). There was no birth weight difference between the breastfed and bottle-fed groups when this infant was excluded from the analysis. Because exclusion of this infant from the regression analyses did not change the pattern or significance levels of the findings, he was included in the sample.

Table 2 shows the unadjusted scores on the McCarthy Scales, the PPVT-R, and the WISC-R for the children in the two groups. Although all test scores were normalized to a mean (\pm SD) value of 100 ± 15 , the population mean for the WISC-R had risen to 108, because of its previous standardization in 1974.⁴⁴ These data confirm in a predominantly full-term sample the findings of Lucas et al¹⁵ and others¹⁶⁻¹⁹ that children who were breastfed as infants score significantly higher on IQ tests in later years and extend these findings to include 11 years of age. These effects were demonstrated on three different measures of intellectual performance at 4 and 11 years. The number of weeks of breastfeeding was related significantly to four of the five McCarthy Scales with the association with the Verbal Scale being the strongest ($r = .25$; $P < .0001$), as in the British study. The association with the fifth McCarthy scale, Quantitative, fell short of statistical significance ($r = .10$; $P = .07$). At 11 years, the number of weeks of breastfeeding was associated significantly with the WISC-R Verbal and Full Scale IQ and with all the WISC-R Verbal subscales with the relation to Vocabulary and Comprehension being the strongest ($r = .18$ and $.17$; $P < .005$, respectively).

Hierarchical multiple regression analyses were used to adjust for the four confounding factors shown in Table 1. Although weakened, the beneficial effect of breastfeeding remained significant after inclusion of social class and education for the McCarthy GCI and the child PPVT-R at 4 years and the WISC-R Verbal and Full Scale IQs at 11 years (Table 3), confirming the results of Lucas et al.¹⁵ However, the inclusion of two direct measures of parental input, maternal IQ and the HOME score in the next step of the regression, reduced the breastfeeding, social class, and educational influences to nonsignificant levels. These data suggest that the association between breastfeeding and childhood IQ is attributable largely to differences in intellectual ability and quality of parenting between breastfeeding and non-breastfeeding mothers.

At 11 years, achievement tests were also adminis-

TABLE 3. Effects of Breastfeeding at Ages 4 and 11 Years, After Adjustment for Maternal Characteristics

	McCarthy GCI (N = 321)		PPVT-R (Child) (N = 319)		Verbal IQ (N = 278)		Performance IQ (N = 278)		Full Scale IQ (N = 278)	
	r	β†	r	β†	r	β†	r	β†	r	β†
Step 1:										
Breastfeeding	.21****	.21****	.24****	.24****	.20****	.20****	.11	.11	.19***	.19***
Step 2:										
Breastfeeding	.21****	.12**	.24****	.14***	.20****	.13*	.11	.06	.19***	.12*
Social class	.34****	.21**	.36****	.17***	.28****	.16**	.21****	.14	.29****	.17**
Education	.32****	.17**	.36****	.22****	.28****	.16**	.19***	.11	.28****	.17**
Step 3:										
Breastfeeding	.21****	.06	.24****	.08	.20****	.07	.11	.02	.19***	.06
Social class	.34****	.06	.36****	.05	.28****	.06	.21****	.07	.29****	.07
Education	.32****	.04	.36****	.10	.28****	.08	.19***	.06	.28****	.09
Maternal IQ	.39****	.14**	.42****	.19***	.39****	.25****	.22****	.09	.36****	.20***
HOME score	.51****	.38****	.46****	.29****	.33****	.15**	.25****	.15*	.34****	.17***

From a hierarchical multiple regression analysis.

† Standardized regression coefficient, adjusts for influence of other variables at that step in the model.

* $P < .05$; ** $P < .025$; *** $P < .01$; **** $P < .001$.

TABLE 4. Effects of Breastfeeding on Woodcock Achievement Scores at 11 Years, After Adjustment for Maternal Characteristics

	Word Comprehension (N = 277)		Passage Comprehension (N = 227)		Reading Comprehension (N = 277)	
	r	β†	r	β†	r	β†
Step 1:						
Breastfeeding	.16****	.16****	.16****	.16****	.17****	.17****
Step 2:						
Breastfeeding	.16****	.10*	.16****	.12**	.17****	.12**
Social class	.21****	.08*	.14***	.01	.19****	.05
Education	.25****	.19****	.22****	.19****	.24****	.19****
Step 3:						
Breastfeeding	.16****	.02	.16****	.05	.17****	.04
Social class	.21****	.04	.14***	.09	.18****	.06
Education	.25****	.08	.22****	.10	.24****	.09
Maternal IQ	.42****	.35****	.34****	.25****	.39****	.29****
HOME score	.35****	.19****	.28****	.16***	.32****	.18****

† Standard regression coefficient, adjusts for influence of other variables at that step in the model.

* $P < .10$; ** $P < .05$; *** $P < .025$; **** $P < .01$; ***** $P < .001$.

tered to the children. No between-group differences were found on the Wide Range Achievement Test-Revised Spelling and Arithmetic subtests ($P > .6$). By contrast, achievement scores on the Woodcock Word, Passage, and Reading Comprehension tests were higher for breastfed than for bottle-fed children (Table 4). As with the IQ scores, the relations between breastfeeding and achievement scores were significant after inclusion of social class and maternal education but not after inclusion of maternal IQ and the HOME scores.

Lastly, we added interaction terms for feeding by maternal IQ and feeding by HOME score to the regression analyses to determine if the effects of breastfeeding may be particularly beneficial to children from families providing less optimal intellectual stimulation. No significant interaction effects were found (all P values $> .20$).

DISCUSSION

The high incidence of breastfeeding in this sample reflects the middle-class status of the mothers in this cohort and the popularity of breastfeeding at the time of recruitment (1980 through 1981). Breastfeeding more than doubled in the United States between 1965 and 1982, when it peaked at 61.9% in a national

survey.¹⁴ Although it declined ~13% between 1984 and 1989, the initiation of breastfeeding again increased by 1995 to 59.7%, almost the level in 1982.

Our findings confirm those of Lucas et al¹⁵ regarding the IQ advantage shown by children who were breastfed as infants¹⁵ and extend these findings to a predominantly full-term sample through 11 years of age, indicating that this advantage is found not only among preterm infants who may be especially sensitive to effects of early nutrition. In both studies, the advantage was shown to be strongest for verbal skills and for infants who were breastfed the longest. In both studies, the effect of breastfeeding was attributable in part to social class and maternal education but remained significant even after these influences were controlled statistically.

Because our study also included direct measures of maternal IQ and parenting skills related to cognitive performance, we were able to adjust for differences in genetic potential and parental behavior. After these more direct measures of parental input were controlled statistically, breastfeeding no longer seemed to affect childhood intellectual function. The mother's decision to breastfeed, particularly for an extended period, presumably reflects her concern with her infant's welfare and her motivation and

ability to stimulate and enrich her child's development, which are at least partially independent of social class and education.

The study by Lucas et al¹⁵ involved a nonrandomized comparison of preterm infants fed breast milk or formula, resulting in comparisons that may have been confounded by socioenvironmental differences between breastfeeding and nonbreastfeeding mothers that were not controlled adequately by maternal social class and education. Moreover, the standard formula that was provided may have been nutritionally inadequate for preterm infants. In a subsequent randomized multicenter study,²⁷ preterm infants fed a standard-term formula for 1 month performed more poorly at 18 months than those given a nutrient-enriched preterm formula. However, in this randomized study, no differences were found in outcome at 18 months between preterm infants fed donor breast milk and those fed an enriched preterm formula. These findings indicate the important nutritional benefits of breast milk or an equivalent enriched formula for preterms, but their implications for full-term infants are questionable because, when the sample was assigned randomly breast milk or a nutritionally appropriate formula, no intellectual differences were found. The lack of differences between preterms randomly fed breast milk or an appropriate formula is consistent with our findings that the correlation of breastfeeding with more optimal cognitive function is actually attributable to quality of parental intellectual endowment or stimulation unless the infant formula is nutritionally deficient. Had random assignment not been used in the British multicenter study, breastfed infants might have seemed to perform more optimally than infants fed enriched preterm formula.

Although the findings in our study cast doubt on the nutritional advantages of breast milk on neurodevelopment in full-term infants and the conclusion that breastfeeding improves childhood intellectual performance, they have no bearing on evidence of the medical benefits of breastfeeding, which have been demonstrated in other studies, or on the need to provide nutritionally adequate formula for preterm or other nutritionally deprived or at-risk infants.

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