

3. EFFECT OF BREASTFEEDING ON INTELLECTUAL AND MOTOR DEVELOPMENT

The studies described below explore the link between breastfeeding and children's development. Studies cover differences in test results between breastfed and non-breastfed children and possible biological explanations for a causal link between breastfeeding and intellectual and motor development.

Mortenson EL, Michaelsen KF, Sanders SA, Reinisch JM. The association between duration of breastfeeding and adult intelligence, JAMA 2002;287:2365-2371.

COUNTRY: Denmark

SETTING: Urban (Copenhagen)

DESIGN: Prospective birth cohort; comprising 2 samples: 1) 973 men and women and 2) 2280 men

BREASTFEEDING DEFINITION: 5 categories of breastfeeding duration assessed by physician interview at 1 year: ≤ 1 , 2–3, 4–6, 7–9, and >9 months.

OUTCOME MEASURE: Test scores on the Danish version of the Wechsler Adult Intelligence Scale (WAIS), including Verbal, Performance and Full scales (sample 1) and the Børge Priens Prøve (BPP) (sample 2). The BPP is an intelligence test administered at the compulsory registration of all Danish males for the military draft at age 18.

RESULTS: After adjusting for a variety of factors, there was a dose-response relationship between breastfeeding duration and all IQ measures (Verbal, Performance and Full scales of the WAIS and the BPP). This duration effect appeared to be non-linear with individuals in the last two duration categories (7–9 and >9 months) having similar test results. The adjusted difference between test scores of individuals breastfed for <1 months and those breastfed for 7–9 months was 6.6 points for the Full Scale WAIS and 2.1 points for the BPP, representing one half and one fifth of a standard deviation, respectively.

METHODOLOGICAL ISSUES: The regression analysis adjusted for a wide variety of potentially confounding variables, interactions and non-linear effects.

Dewey KG, Cohen RJ, Brown KH, et al. Effects of exclusive breastfeeding for four versus six months on maternal nutritional status and infant motor development: Results of two randomized trials in Honduras. J Nutr 2001;131:262–7.

COUNTRY: Honduras

SETTING: Maternity hospitals in San Pedro Sula

DESIGN: Prospective observational study for the first 4 months of life, followed by a randomized intervention trial from 4 to 6 months and a follow-up period for the second half of the first year. Trial 1 consisted of 141 infants of women from low socioeconomic status; Trial 2 consisted of 119 low birth weight infants. All infants were exclusively breastfed (EBF) from birth to 4 months and then randomized to EBF until 6 months or to introduction of solid foods at month 4.

BREASTFEEDING DEFINITION: Exclusive breastfeeding defined as receiving only breastmilk

OUTCOME MEASURE: Maternal body mass index, duration of lactational amenorrhea, and infant motor development (following 10 motor milestones)

RESULTS: Infants who only received breastmilk for the first 6 months of life crawled sooner and were more likely to walk by 12 months of age than infants who received solid foods starting at 4 months. Infants in the EBF group also were marginally (but significantly) able to sit earlier than those who received solids by 4 months of age.

METHODOLOGICAL ISSUES: All groups in both studies were exclusively breastfed until 4 months and continued to receive some amount of breastmilk past 6 months. Since neither study had a formula-only group, it can be assumed that the developmental differences observed would be stronger in situations where the differences in infant feeding practices are less subtle.

Horwood LJ, Darlow BA, Mogridge N. Breast milk feeding and cognitive ability at 7-8 years. Arch Dis Child Fetal Neonatal Ed 2001; 84:F23-F27.

COUNTRY: New Zealand

SETTING: Nationwide

DESIGN: Prospective, n=280 survivors of a cohort of 413 very low birth weight infants born in 1986 and assessed at 7-8 years of age

BREASTFEEDING DEFINITION: Not breastfed, breastfed < 4 months, 4-7.9 months, \geq 8 months

OUTCOME MEASURE: Verbal and performance IQ scores using the revised Wechsler intelligence scale for children

RESULTS: Breastfeeding duration was significantly related to both verbal and performance IQ test scores. Infants breastfed for 8 months or longer had a verbal IQ score 10.2 points higher and a performance IQ score 6.2 points higher on average than those of non-breastfed infants. After adjusting for potentially confounding factors, these advantages were reduced to 6.0 points in the case of verbal IQ and to statistical non-significance in the case of performance IQ.

METHODOLOGICAL ISSUES: A variety of perinatal and household socio-economic and demographic factors were controlled for in multiple regression analysis.

Anderson JW, Johnstone BM, Remley DT. Breast-feeding and cognitive development: A meta-analysis. Am J Clin Nutr 1999;70:525-35.

COUNTRY: Multicountry (United Kingdom, United States, Australia, Germany, New Zealand, and Spain)

SETTING: Urban and rural

DESIGN: Meta-analysis of 20 observational cohort and case-control studies, including low or normal birth weight infants

BREASTFEEDING DEFINITION: Predominantly breastfed versus predominantly formula-fed and breastfed. Breastfed group was pooled for duration into: 4–7, 8–11, 12–19, 20–27, and ≥ 28 wks.

OUTCOME MEASURE: The most commonly used tests of cognitive development were the Bayley Mental Development Index (12 observations), the Peabody Picture Vocabulary Test (6 observations), the General Cognitive Index of the McCarthy Scales of Children's Abilities (5 observations), the Wechsler Child Intelligence Scale (4 observations), and the Stanford-Binet Intelligence Scale (2 observations).

RESULTS: The average unadjusted pooled mean benefit in cognitive development score of breastfeeding, compared with formula feeding, ranged from 5 to 6 points. After adjustment, the difference declined to 3.16 points, but remained significant. The group deriving the greatest benefit from breastfeeding was low birth weight children, with an average adjusted benefit of 5.18 points across the 6 studies available. This was significantly higher than the average adjusted increment of 2.66 points observed for breastfed children born with normal weight. A significant benefit was observed as well for longer breastfeeding duration. The results showed a gradual increase in the magnitude of the benefit in cognitive development correlated to breastfeeding exposure as it increased from 8 to 11 weeks (weighted mean benefit of 1.68 points) to ≥ 28 weeks (weighted mean benefit of 2.91 points).

METHODOLOGICAL ISSUES: Appropriately conducted meta-analysis with careful specificity of criteria for study selection, quality assessment, and control of confounding variables.

Horwood LJ, Fergusson DM. Breastfeeding and later cognitive and academic outcomes. Pediatrics 1998;101(1):e9.

COUNTRY: New Zealand

SETTING: Christchurch urban population

DESIGN: Longitudinal cohort study (n > 1,000 children), studied at birth, 4 months, 1 year, at annual intervals thereafter to 16 years of age, and again at age 18

BREASTFEEDING DEFINITION: Exclusive breastfeeding was defined as receiving breastmilk, to age of 4 months, without any additional cow's milk, milk formula preparation, or solid food. Other categories included not breastfed, breastfed for < 4 months, breastfed for 4–7 months, and breastfed for ≥ 8 months.

OUTCOME MEASURE: Child's cognitive ability and academic achievement (using a variety of tools) from 8 to 18 years of age

RESULTS: Breastfeeding was significantly associated with higher scores of cognitive ability, teacher ratings, standardized achievement tests, and increased high school success. The duration of breastfeeding was positively associated with cognitive ability and academic success levels from middle childhood to school graduation. However, after controlling for social and family differences, the strength of the associations was reduced; suggesting that breastmilk was not the sole factor affecting cognitive ability and academic performance. Nonetheless, small but consistent tendencies were observed for an association between increasing duration of breastfeeding and increased IQ scores, performance on standard achievement tests, teacher ratings, and high school achievement.

Even after statistical adjustment, children who received breastmilk for ≥ 8 months had higher test scores than those who were not breastfed.

METHODOLOGICAL ISSUES: Multiple regression analyses were performed to study associations between duration of breastfeeding and cognitive ability into adulthood, and between breastfeeding and indices of academic achievement. Statistical significance was tested by one-way analysis of variance and the dichotomous measure by χ^2 test of independence. Confounding factors included measures of social, family, and others known to have an association with a mother's decision to breastfeed and/or with cognitive and academic outcomes. Mothers who breastfed tended to have higher socioeconomic status and were less likely to be single parents than mothers who did not breastfeed.

Wang YS, Wu SY. The effect of exclusive breastfeeding on development and incidence of infection in infants. *J Hum Lact* 1996;12:27–30.

COUNTRY: China

SETTING: Xu Hui District, Shanghai

DESIGN: Prospective population-based study of infants aged less than 1 year (n = 145)

BREASTFEEDING DEFINITION: Exclusive breastfeeding for at least 4 months and partial breastfeeding (including no breastfeeding) for the first 4 months of life

OUTCOME MEASURE: Physical development determined by weight and height, development assessment measured using the Denver Developmental Screening Test and cumulative incidence of infectious diseases including respiratory, gastrointestinal, and skin infections

RESULTS: Infants who were exclusively breastfed had significantly higher mean body weight at 4 months than those who were not exclusively breastfed (7.46 ± 0.74 versus 7.18 ± 0.89 kg, $p < 0.05$). At 1 year, mean Gross Motor Development scores were 47.37 for exclusively breastfed children, compared with 30.68 for nonexclusively breastfed children. Furthermore, 30 exclusively breastfed children had failed the Gross Motor Development Assessment, compared with 61 in the nonexclusively breastfed group ($p < 0.05$).

METHODOLOGICAL ISSUES: No comparison was provided between the mothers of the infants exclusively breastfed and the mothers of those partially breastfed.

de Andraca I, Uauy R. Breastfeeding for optimal mental development: The alpha and omega in human milk. *World Rev of Nutr Diet* 1995;78:1–27.

These review articles summarize the results of many of the studies included in this bibliography. They also discuss specific breastmilk components, particularly essential fatty acids and research results that examine possible mechanisms whereby breastmilk may have an effect on later intelligence. The article concludes that all results comparing breastfeeding with bottle feeding need to be interpreted cautiously because of the potential for confounding. The authors suggest that the effects of breastfeeding are

complex and related to both the nutritional properties of breastmilk and the emotional and bonding factors associated with the process of breastfeeding, and their interaction. The article also concludes that the challenge in future studies will be to establish a conceptual framework that enables these separate and interactive effects to be disentangled. They argue further that breastfeeding should be considered best unless proven otherwise, and that it is particularly important in developing countries and among underprivileged communities in developed countries.

Florey CDV, Leech AM, Blackhall AA. Infant feeding and mental and motor development at 18 months of age in first born singletons. Inter J Epidem 1995;S21–6.

COUNTRY: Scotland

SETTING: Dundee (urban)

DESIGN: Population-based prospective/retrospective: n = 592

BREASTFEEDING DEFINITION: Breastfed versus bottle-fed, as assessed from hospital discharge records and home health visits

OUTCOME MEASURE: Bayley Mental and Motor Developmental Indices

RESULTS: The study population consisted of 846 firstborn singletons born during a 1-month period in 1986, of whom 592 were assessed for mental and motor development at 18 months of age. Potentially confounding factors controlled in the analysis included partner's social class; maternal age, height, education, cigarette and alcohol consumption during pregnancy; and the infant's sex, birth weight, gestational age, and placental weight. Unadjusted analyses showed that the whole distribution of scores for mental outcomes for bottle-fed children was lower, which suggests that whatever is influencing scores affects children over the entire range of mental abilities. The unadjusted mean difference was 7.7 points (110.2 for breastfed and 102.5 for bottle-fed children). No consistent difference was found for the motor development indices. Regression analyses, which controlled for potentially confounding factors, showed a significant difference in mental developmental indices of between 3.7 and 5.7 points, depending on the source of the infant feeding data. The feeding data were not completely concordant for all children.

METHODOLOGICAL ISSUES: Breastfeeding is poorly defined, and it is not clear what the duration of breastfeeding was among the breastfed cohort. Nonetheless, these data were not collected as part of the study on mental and motor development but were available from birth and early health records. One psychologist performed all the tests and was blinded to the infant feeding mode.

Greene LC, Lucas A, Livingstone MBE, et al. Relationship between early diet and subsequent cognitive performance during adolescence. Biochem Soc Trans 1995;23:376S.

COUNTRY: England

SETTING: South Tees area

DESIGN: Retrospective: n=432 subjects aged 11–16 years

BREASTFEEDING DEFINITION: Breastfed versus not breastfed as assessed by medical records; duration of breastfeeding (1–12 weeks and > 12 weeks)

OUTCOME MEASURE: Cognitive ability as assessed by the Raven Standard Progressive Matrices and subtests of the Primary Mental Abilities test

RESULTS: This study examined whether breastfeeding was associated with differences in IQ between 11 and 16 years of age. Breastfeeding was positively associated with social class and education. Firstborn children also were significantly more likely to be breastfed. Unadjusted results show breastfeeding to be significantly and positively associated with IQ scores. However, these differences disappeared when analyses were adjusted for potentially confounding factors. In these analyses, social class, birth rank, and maternal age were significant. The effect of breastfeeding duration was also assessed for the following breastfeeding categories: 1) 1–12 weeks and > 12 weeks. No significant differences in birth weight, gestational age, birth rank, child's sex, maternal age, maternal education, and social class were found between the 2 groups. A significant 6-point advantage in verbal IQ and a 5.4-point advantage in reasoning IQ was found after adjustment for potentially confounding factors for infants breastfed for > 12 weeks.

METHODOLOGICAL ISSUES: Authors controlled for many known potentially confounding factors. One strength of the study is that it looks at the relationship between breastfeeding duration and development. Because all mothers in this subanalysis breastfed, this is likely to control better for familial factors associated with maternal decisions to breastfeed and contribute toward child development.

Uauy R, de Andraca I. Human milk and breastfeeding for optimal mental development. *J Nutr* 1995;125:2278S–2289S.

(The results of this study were the same as *de Andraca I, Uauy R. Breastfeeding for optimal mental development: The alpha and omega in human milk. World Rev Nutr Diet* 1995;78:1–27; therefore, we chose to only summarize one of them, while making reference to both).

Lucas A, Morley R, Cole TJ, Gore SM. A randomized multicentre study of human milk versus formula and later development in preterm infants. *Archives Dis Child* 1994;70:F141–6.

COUNTRY: England

SETTING: 3 neonatal clinics

DESIGN: Randomized trial: children (n = 502) who were preterm and < 1850 g at birth and followed for 18 months. Two separate studies were conducted, and the results were reported in several articles. In the first 3-center study, infants whose mothers chose not to use their own breastmilk were randomized to receive a special high-protein and calorie preterm formula or banked donor breastmilk (Trial A). Infants whose mothers chose to provide their own expressed breastmilk were randomly assigned to receive the preterm formula or banked donor breastmilk to supplement their own breastmilk as needed (Trial B). In Trial B, the proportion of breastmilk provided by the mother ranged from 0% to 100%, with a median of 53%. There were no differences in the proportion of maternal breastmilk provided between the two treatment groups. In a separate 2-center study, infants whose mothers chose not to breastfeed were randomized to receive a

regular-term formula or the special preterm formula (Trial A). Infants whose mothers chose to provide expressed breastmilk were randomly assigned to receive term formula or preterm formula to supplement maternal breastmilk as needed (Trial B). Thus, within studies, trials A and B can be treated independently or combined to compare the banked breastmilk or term formulas versus the preterm formula as the sole diet or in combination with the mother's own expressed breastmilk.

BREASTFEEDING DEFINITION: Banked breastmilk versus special preterm formula (Trial A) and banked breastmilk and expressed maternal breastmilk versus preterm formula and expressed maternal breastmilk (Trial B). Both treatments were provided to the infants by nasogastric tube.

OUTCOME MEASURE: Bayley psychomotor and mental development indices at 18 months of age

RESULTS: Children who were fed the special preterm formula had better motor and mental development outcomes at 18 months of age than children who received a standard formula (see Lucas et al., 1992). Thus, the formula used in the present study was the "best" available.

There were no significant developmental differences at 18 months between the children receiving the preterm formula and those receiving banked breastmilk as either the sole diet (Trial A) or in combination with the expressed maternal breastmilk (Trial B). Male children who had received preterm formula had a 7.6 point advantage on the Bayley psychomotor development test over male children receiving banked breastmilk, but this difference was not statistically significant. When the children fed banked breastmilk and standard formula were compared (using data from both studies and, hence, breaking the randomized design), children fed banked breastmilk had significantly higher scores. In this nonrandomized comparison, children fed banked breastmilk scored 8.8 points higher on the Bayley index of psychomotor development than those fed standard formula. The differences in mental development favored children fed banked breastmilk over children receiving term formula, but these differences did not reach statistical significance.

METHODOLOGICAL ISSUES: Randomization permits the effect of breastmilk to be evaluated in a manner that is not confounded by social and educational differences between mothers who chose to breastfeed and those who do not. Interviewers who administered the Bayley Developmental Tests were blinded to infant feeding status. Although the design was intended to control for self-selection in choice of infant feeding mode, the most interesting results of the study were the comparisons that broke this design and compared the banked breastmilk to term formula, which were treatments from two different studies. The extent to which results from very low birth weight infants are representative of normal weight infants is unknown.

Pollock JI. Long-term associations with infant feeding in a clinically advantaged population of babies. *Develop Med Child Neurol* 1994;36:429–40.

COUNTRY: England

SETTING: Nationwide

DESIGN: Prospective/retrospective: n = 3838 children born within a 1-week period in 1970 and assessed at 5 and 10 years of age

BREASTFEEDING DEFINITION: Exclusively breastfed for 3 months or more versus bottle-fed

OUTCOME MEASURES: Health, physical, and developmental assessments through a vocabulary test at 5 years and intellectual assessment through the British Ability Scales test at 10 years

RESULTS: This methodologically rigorous study compares the physical, health, and developmental differences between 2 cohorts of children: those who had been exclusively breastfed for 3 or more months and those who had been bottle-fed, excluding clinically disadvantaged infants. The potentially confounding effect of 76 variables was assessed, and a hierarchical regression procedure was used to identify and include potentially confounding factors in the final model. Adjusted odds ratios and their 99% confidence intervals were presented. Exclusive breastfeeding was positively associated with both maternal and paternal education and maternal attendance at prenatal classes and negatively associated with maternal smoking. At 5 years of age, a total of 22 outcomes related to medical history and physical and mental development were assessed. The 3 intellectual development tests administered were a picture-based vocabulary test, drawing a human figure, and copying a simple design.

The authors estimate that using the 2-tailed threshold for significance, the expected number of chance associations was 0.2. Of the 22 outcomes, only the picture vocabulary test was significantly and positively associated with exclusive breastfeeding. At 10 years of age, a total of 24 medical, 7 physical, and 8 intellectual factors were assessed. The expected number of significant chance associations was 0.4. None of the medical or physical factors was associated with infant feeding mode, but exclusively breastfed children scored significantly higher on 4 of the tests for intellectual development. Linear regression on actual scores showed that exclusively breastfed infants scored 2.6 to 3.5 points higher in a population mean of 100 on the British Ability Scales for word definitions (involving retrieval and application of knowledge), matrices, similarities (involving reasoning skills), and total score (measuring overall perceptual and cognitive ability).

The authors conclude that the study supports the hypothesis that some aspects of intellectual attainment can be demonstrated to be superior among children who were exclusively breastfed for at least 3 months, compared with their bottle-fed counterparts—after early clinically disadvantaged bottle-fed children were excluded from the analysis, and remaining potentially confounding factors were controlled.

METHODOLOGICAL ISSUES: As with the other studies in this area, uncontrolled confounding may at least partly explain the results observed.

Rogan WJ, Gladen BC. Breast-feeding and cognitive development. *Early Hum Dev* 1993;31:181–93.

COUNTRY: United States

SETTING: North Carolina (hospital and clinic-based)

DESIGN: Prospective: birth cohort of children assessed at different ages up to age 5 years (initial n = 855)

BREASTFEEDING DEFINITION: Breastfeeding duration divided into 4 categories (short, medium, long, very long), bottle feeding

OUTCOME MEASURE: Bayley Scales of Infant Development at 6, 12, 18, and 24 months; subscales of both mental and psychomotor development; McCarthy Scales at 3, 4, and 5 years; report cards at third grade

RESULTS: This study examined whether breastfeeding was associated with differences in mental and motor skills at various age intervals up to 5 years of age and with school performance in third grade. The unadjusted results show that there was a tendency for the Bayley Mental Development Index to be higher among breastfed infants than among bottle-fed infants, and to be higher among those breastfed infants who were breastfed for longer durations. After adjustment for potentially confounding factors, children breastfed the shortest had scores 1 to 3 points lower than those bottle-fed, and 3 to 7 points lower than those breastfed the longest. Differences were significant only at 24 months of age, however.

The results from the Psychomotor Development Index were similar, with a tendency for slightly higher scores among children breastfed for longer durations, and with differences among groups significant only at 24 months. With respect to the McCarthy Scale, children breastfed the longest had a tendency toward higher scores (2 to 4 points) than children breastfed the shortest. These differences were significant at 3 and 4 years, but only marginally so at 5 years. Duration of breastfeeding was marginally associated with both English and math grades at third grade. However, after adjustment for potentially confounding factors, the differences were only marginally significant for English and not significant for math. The difference between children bottle-fed and breastfed the shortest was 0.17 points, and between children breastfed the shortest and breastfed the longest, the difference was 0.06 points.

The authors conclude that there were small but significant advantages for breastfed children on some Bayley and McCarthy subscales at all time points from 2 through 5 years of age. This advantage was more consistent for cognitive than motor skills (which is consistent with other studies).

METHODOLOGICAL ISSUES: Although the authors controlled for many known potentially confounding variables, mothers who chose to breastfeed may have had other characteristics associated with child development that could explain the results.

Lucas A, Morley R, Cole TJ, Lister G, Lesson-Payne C. Breast milk and subsequent intelligence quotient in children born preterm. *Lancet* 1992;339:261–4.

COUNTRY: England

SETTING: 5 neonatal clinics

DESIGN: Prospective: children (n = 300) who were preterm and < 1850 g at birth and followed for about 8 years

BREASTFEEDING DEFINITION: Maternal expressed breastmilk exclusively, or in combination with formula, versus formula; proportion of total intake provided by maternal breastmilk

OUTCOME MEASURE: Intelligence quotient (IQ) at 7 to 8 years of age

RESULTS: This study examined whether having been fed breastmilk through a nasogastric tube early in life was associated with intelligence quotient at 7 to 8 years of age. Because breastmilk was delivered to the infant by nasogastric tube, the authors were able to examine the effect of breastmilk on subsequent intelligence rather than the actual process of breastfeeding. There was a significant dose-response relationship between the proportion of breastmilk provided to the infant and intelligence ($p < 0.05$). The effect was greatest for the verbal scale, where a 9-point difference was found between those infants who consumed 100 percent breastmilk and those infants who consumed no breastmilk. Children of mothers who chose to provide breastmilk, but were unable to do so, had intelligence quotients similar to children whose mothers did not choose to provide breastmilk. Overall, differences in intelligence quotient between those children who received some breastmilk and those who received none was 8.3 points. The data were adjusted for maternal education, social class, days the infant was on a ventilator, and infant sex, which also were associated with intelligence quotient. The effect of early breastmilk feeding, however, was stronger than any of these factors. The effects of early breastmilk feeding on intelligence quotient in preterm infants are larger than the effects for full-term infants. The authors suggest that preterm infants are especially vulnerable to the effects of early nutrition.

METHODOLOGICAL ISSUES: Mothers who provided breastmilk were of a higher social class and educational level, which may be associated with parenting attributes that are not completely captured by these two measures. The authors state that the results could be explained by differences between the groups in parenting skills or genetics even after adjustment for social class and maternal education.

Morrow-Tlucak M, Haude RH, Ernhart CB. Breastfeeding and cognitive development in the first 2 years of life. *Social Sci & Med* 1988;26(6):635–9.

COUNTRY: United States

SETTING: Inner city

DESIGN: Prospective: Children (n = 229) at risk for developmental delay

BREASTFEEDING DEFINITION: Duration of breastfeeding as a continuous variable or categorized as follows: 0, < 4 months, > 4 months

OUTCOME MEASURE: Bayley Motor Development Test at 6 months, 1 and 2 years, and the Home Observation for Measurement of the Environment at 1 and 2 years

RESULTS: This study examined whether breastfeeding was associated with differences in mental and motor development during the first 2 years of life. Breastfeeding was associated with significantly increased scores on the Bayley Mental Development Index. At 12 and 24 months, scores were about 2.5 points higher for children breastfed > 4 months than for those breastfed < 4 months ($p < 0.001$). Differences at 6 months favored breastfeeding, but failed to reach statistical significance. Mothers who breastfed were more likely to have more education and be older and married. Because these are also characteristics that might independently and positively influence child development, they were controlled for in the analysis.

METHODOLOGICAL ISSUES: The authors acknowledge that the observed differences may be at least partly due to uncontrolled maternal social factors.

Taylor B, Wadsworth J. Breastfeeding and child development at five years. Dev Med Child Neurol 1984;26:73–80.

COUNTRY: United Kingdom

SETTING: Nationwide

DESIGN: Prospective/retrospective cohort study, $n=13,135$ children born within a one-week period in 1970 and assessed at five years of age

BREASTFEEDING DEFINITION: Not breastfed, breastfed < 1 month, 1–2.9 months, ≥ 3 months.

OUTCOME MEASURE: The English Picture Vocabulary Test, Copying Designs Score, and the Rutter Child Behavior Score.

RESULTS: The duration of breastfeeding was associated with improved scores on the three tests but, after controlling for potentially confounding factors, the association with the Rutter Score was non-linear and only marginally significant ($p=0.046$). The associations with the other two tests were attenuated but remained significant ($p<0.001$). The authors suggest that despite the statistical significance of the adjusted results the magnitudes of these effects were small.

METHODOLOGICAL ISSUES: The analysis controlled for a variety of potentially confounding factors including socio-economic status and “home furnishings and equipment,” maternal age, maternal smoking, and number of siblings. However, by also including other behavioral measures as covariates in the analysis (for example the Rutter Child Behavior Score is cited as a significant covariate in the analysis of the relationship between breastfeeding duration and the vocabulary scores), the true effect of breastfeeding on child development may have been underestimated in the adjusted analysis.

Fergusson DM, Beautrais AL, Silva PA. Breast-feeding and cognitive development in the first seven years of life. *Soc Sci & Med* 1982;16:1705–8.

COUNTRY: New Zealand

SETTING: Dunedin

DESIGN: Prospective: birth cohort of children assessed at age 3 (n = 1,037), age 5 (n = 997), and age 7 years (n = 954)

BREASTFEEDING DEFINITION: Breastfed > 4 months, breastfed < 4 months, bottle fed

OUTCOME MEASURE: Measures of intelligence at 3, 5, and 7 years. The 3-year-old measure was based on the Peabody Picture Vocabulary Test, the 5-year measure on the Stanford Binet Intelligence Scale, and the 7-year measure on the Weschler Child Intelligence Scale. Language development was also measured at the 3 ages and articulation at ages 5 and 7 years.

RESULTS: This study examined whether breastfeeding was associated with differences in 11 indicators of intelligence and language development at ages 3, 5, and 7 years. The unadjusted results show that there was a tendency for test scores to vary with the duration of breastfeeding among children breastfed 4 months or longer. On tests that had a standard deviation of 10, scores of these children were 1.90 to 5.55 (mean = 3.84) points higher than those of bottle-fed children. Although adjustment for 7 co-variables (maternal intelligence, maternal educational level, maternal training in child rearing, child experience, family socioeconomic status, child's birth weight, and gestational age) attenuated these differences, breastfed children still had significantly higher scores (by 0.82 to 2.71 (mean = 1.89) points). There was no sex-breastfeeding interaction, which indicates that sexes do not respond differently to the effect of breastfeeding on intelligence.

METHODOLOGICAL ISSUES: The authors conclude that breastfeeding may be associated with very small improvements in intelligence and language development. Alternatively, the difference may have been due to the effects of other confounding factors not entered into the analysis.

Rodgers B. Feeding in infancy and later ability and attainment: A longitudinal study. *Develop Med Child Neurol* 1978;20:421–6.

COUNTRY: England

SETTING: Nationwide

DESIGN: Prospective: survey sample of live births (n = 5,362) followed for 15 years

BREASTFEEDING DEFINITION: Duration of any breastfeeding and duration of bottle-feeding

OUTCOME MEASURE: Tests of picture intelligence and mechanical word reading at 8 years of age and scores for reading attainment, nonverbal ability, and mathematical attainment at 15 years of age

RESULTS: This study examined whether breastfeeding was associated with differences in mental and motor development at 8 and 15 years in a cohort of children followed prospectively from birth. Breastfeeding was found to be more common in families of

higher social class, higher educational levels, and that showed greater interest in the child's primary education. Multivariate analyses were performed to control for these potentially confounding factors. Breastfeeding was associated with significantly increased scores on 4 of the 5 outcomes examined: these included picture intelligence in children 8 years of age (1.76 points), nonverbal ability (1.76 points), mathematics (1.55 points), and sentence completion (1.73 points) in children 15 years of age.

METHODOLOGICAL ISSUES: Although the authors controlled for most known potentially confounding factors, the fact that breastfeeding was associated with other familial attributes that contribute to intellectual development makes it difficult to rule out uncontrolled confounding in the reported associations.
