Effect of breast feeding on intelligence in children: prospective study, sibling pairs analysis, and meta-analysis

Geoff Der, G David Batty, Ian J Deary

Abstract

Objective To assess the importance of maternal intelligence, and the effect of controlling for it and other important confounders, in the link between breast feeding and children's intelligence.

Design Examination of the effect of breast feeding on cognitive ability and the impact of a range of potential confounders, in particular maternal IQ, within a national database. Additional analyses compared pairs of siblings from the sample who were and were not breast fed. The results are considered in the context of other studies that have also controlled for parental intelligence via meta-analysis.

Setting 1979 US national longitudinal survey of youth.

Subjects Data on 5475 children, the offspring of 3161 mothers in the longitudinal survey.

Main outcome measure IQ in children measured by Peabody individual achievement test.

Results The mother's IQ was more highly predictive of breastfeeding status than were her race, education, age, poverty status, smoking, the home environment, or the child's birth weight or birth order. One standard deviation advantage in maternal IQ more than doubled the odds of breast feeding. Before adjustment, breast feeding was associated with an increase of around 4 points in mental ability. Adjustment for maternal intelligence accounted for most of this effect. When fully adjusted for a range of relevant confounders, the effect was small (0.52) and non-significant (95% confidence interval −0.19 to 1.23). The results of the sibling comparisons and meta-analysis corroborated these findings.

Conclusions Breast feeding has little or no effect on intelligence in children. While breast feeding has many advantages for the child and mother, enhancement of the child's intelligence is unlikely to be among them.

Introduction

Observational studies of term infants examining the link between breast feeding and intelligence are hampered by confounding. Those potential confounding variables singled out as particularly important include socioeconomic status, maternal education, and birth weight[1] or socioeconomic status/parental education and stimulation of the child.[2] Maternal intelligence is relatively overlooked as a potential confounder. This is surprising given the heritability of intelligence[3] and the known association of maternal intelligence with both the initiation and duration of breast feeding.[4]

We examined the relation between breast feeding and intelligence and assessed the role of maternal IQ and other covariates in generating the association. We took both a conventional approach to control for confounders and an alternative approach using sibling comparison analysis. This approach controls for many confounding factors without having to measure them; any factor that is the same for both members of a pair of siblings is automatically and fully controlled for. Thus, the method implicitly controls for parental intelligence.

Methods

We used data from the US national longitudinal survey of youth 1979 (NLSY79),[5] a population based sample of 12 686 young people (6283 female) aged 14 to 22 when first interviewed in 1979, interviewed annually until 1994, and biennially thereafter. Since 1986 the children of the women in the survey have also been assessed biennially. We excluded children born before the 35th week and those who weighed less than 2500 g at birth.

Measures

Children's cognitive ability—The Peabody individual achievement test (PIAT) was administered to children between the ages of 5 and 14 biennially from 1986 to 2002. Children were tested repeatedly if they fell within the age range in test years. We used the PIAT total scores, as well as the individual component scores for mathematics, reading comprehension, and reading recognition. We standardised all outcomes to a mean of 100 and standard deviation of 15.

Breast feeding—Women who had had a child since the previous interview were asked whether they breast fed the child at all and, if so, how old the child was when they stopped breast feeding. Reports on duration of breast feeding were probably less reliable than reports of whether a child was breast fed or not.

Control variables—We chose control variables on the basis of associations with breast feeding or childhood cognitive development in the survey,[6 7] other studies of breast feeding and cognitive development,[4 8 9] and the most recent reviews of the subject.[1 2 10 11]

Child's environment—The short form of the home observation for measurement of the environment scale (HOME-SF)[12] was completed at each assessment, and we used the cognitive stimulation and emotional support subscales.

Child demographics—Sex, age, gestation (weeks), birth weight, and birth order were also used in the models.

Maternal characteristics—Maternal cognitive ability was measured with the armed forces qualification test (AFQT).[5] It was administered in 1980. We also recorded level of education, race, poverty status, the mother's age at the birth of the child, and whether the mother smoked during the pregnancy (see bmj.com).

This is the abridged version of an article that was posted on bmj.com on 4 October 2006: http://bmj.com/cgi/doi/10.1136/bmj.38978.699583.55

Editorial by Jacobson and Jacobson

MRC Social and Public Health Sciences Unit, Glasgow G12 8RZ
Geoff Der *statistician*
G David Batty *Wellcome fellow*
Department of Psychology, University of Edinburgh, Edinburgh
Ian J Deary *professor of differential psychology*
Correspondence to: G Der Geoff@msoc.mrc.gla.ac.uk

BMJ 2006;333:945–8

Statistical analysis

Linkage of the data from the survey with the child and young adult sample resulted in a dataset that contained one or more assessments for each child and one or more children per mother. The multiple assessments made on each child are unlikely to be statistically independent, nor are the data for siblings. To accommodate this, we used random effects models, which have the advantage of being able to use all available assessments for each child and all children, whether they are siblings or not.

All analyses were carried out separately for PIAT total score and the three subscales: mathematics, reading recognition, and reading comprehension. Initial analysis assessed the association between each of the potential confounders and breast feeding. The main analyses estimated the effect of breast feeding on cognitive ability; examined the extent to which each of the confounders, individually, attenuated the effect; and then examined the attenuation of multiple confounders. See bmj.com for details of the random effects models and sibling comparison analysis.

We considered the results of both types of analysis in the context of other comparable studies via meta-analysis. There are no agreed standards of study quality in this area, and the four recent reviews identified all used different criteria, resulting in sets of studies with relatively little overlap.[1 2 10 11] We included only studies that quantified the effect of breastfeeding status on cognitive ability after controlling for parental intelligence among full term infants. See bmj.com for details.

Results

Descriptive statistics show that children who were breast fed had mothers with higher IQ and with more education and who were older, less likely to be in poverty or to smoke, and more likely to provide a more stimulating and supportive home environment. Hispanic mothers were less likely to breast feed their children and black mothers much less likely. The children who were breast fed were likely to be heavier at birth and earlier in birth order, although this could be a reflection of family size. There was no difference in gestation or the proportion of male infants who were breast fed. See bmj.com.

A one standard deviation advantage in mother's IQ more than doubled of the odds of breast feeding. Mother's education had a similar but slightly weaker effect. As gestation and sex were not significantly associated with breast feeding, they were not included in the remaining analyses. For the analyses of PIAT scores we had full data on 16 744 assessments of 5475 children born to 3161 mothers.

Table 1 shows the effect of breast feeding on the cognitive outcomes, both unadjusted and adjusted individually for each of the confounders. The unadjusted effects of breast feeding correspond to an advantage for those breast fed of 4.1 to 4.7. These are comparable with effects reported in other studies.[10] Adjustment for mother's IQ reduced this advantage by 71% to 75%, and adjusted for mother's education results by 34% to 42%. Family poverty, maternal race, maternal age, and HOME stimulation score were important confounders.

Table 2 shows the results of including all the confounders simultaneously. In this case, each row of the table gives the effect of the confounder on the outcome, adjusted for all the others and for the child's age at assessment. The fully adjusted effect of breast feeding averages slightly less than half a point with a range of 0.36 to 0.52. These are small effects, and none is significant even with the large numbers in these analyses.

We re-ran the models in table 2 omitting maternal IQ. The effects of breast feeding were then at least double those shown in table 2 and all were significant. Although these effects were still small, they do show that omitting maternal intelligence can seriously overestimate the effect of breast feeding.

To assess a dose-response relation we repeated the analysis including data only on those who were breast fed and introducing duration of breast feeding to the model. Although the effects for reading comprehension and PIAT total score were significant, all effects were small (see bmj.com).

Sibling pairs analysis

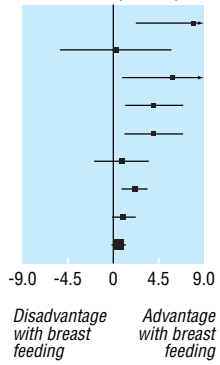
There were 332 sibling pairs discordant for breastfeeding status and 545 discordant for duration of breast

Table 1 Effect of breast feeding on cognitive outcomes, unadjusted and adjusted singly for each confounder, in 3161 mothers, 5475 children, and 16 744 assessments. All significant at P<0.001 except where marked

	PIAT-total		Maths*		Reading*		Comprehension*	
	B (SE)	%†	B (SE)	%†	B (SE)	%†	B (SE)	%†
Unadjusted	4.69 (0.38)		4.65 (0.36)		4.09 (0.38)		4.22 (0.36)	
Adjusted for:								
Mother's AFQT score	1.30 (0.36)	72	1.30 (0.34)	72	1.02 (0.37)‡	75	1.21 (0.35)	71
Mother's education	2.95 (0.37)	37	3.06 (0.35)	34	2.38 (0.37)	42	2.69 (0.35)	36
Family in poverty	3.94 (0.38)	16	3.96 (0.36)	15	3.30 (0.37)	19	3.46 (0.35)	18
Mother's age	4.29 (0.38)	9	4.18 (0.36)	10	3.64 (0.38)	11	3.96 (0.36)	6
Mother smoked in pregnancy	4.60 (0.38)	2	4.60 (0.36)	1	3.98 (0.38)	3	4.14 (0.36)	2
HOME cognitive stimulation	4.29 (0.37)	8	4.20 (0.35)	10	3.66 (0.37)	10	3.64 (0.35)	14
HOME emotional support	4.57 (0.38)	3	4.47 (0.36)	4	3.96 (0.38)	3	4.06 (0.36)	4
Birth weight	4.60 (0.38)	2	4.52 (0.36)	3	4.02 (0.38)	2	4.15 (0.36)	2
Birth order	4.55 (0.38)	3	4.57 (0.36)	2	3.94 (0.37)	4	4.01 (0.35)	5
Race	3.65 (0.38)	22	3.30 (0.36)	29	3.32 (0.39)	19	3.34 (0.37)	21

PIAT=Peabody individual achievement test; AFQT=armed forces qualification test; HOME=home observation for measurement of the environment.
*Individual components of PIAT.
†Percentage of unadjusted figure.
‡P=0.006.

Study name	Statistics for each study: Difference in means (SE)	P value	N	Age (years)	IQ test	SES	Mother: Edn	Mother: Age	Mother: Smoker	HOME	Birth order	Birth weight	Gestation
Hay	7.92 (2.94)	0.007	130	11	WISC	-	-	-	-	Y	-	-	-
Ghys	0.21 (2.82)	0.940	108	4	GOS	-	Y	-	Y	-	-	Y	Y
Morrow-Tlucak	5.83 (2.57)	0.023	219	2	MDI	-	-	Y	Y	Y	-	-	-
Gomez-Sanchiz	3.98 (1.53)	0.009	164	2	MDI	Y	Y	Y	Y	-	Y	-	-
Jacobson	4.00 (1.49)	0.007	279	11	WISC	Y	Y	-	-	Y	-	-	-
Wigg	0.80 (1.37)	0.560	343	12	WISC	Y	-	Y	Y	Y	Y	Y	-
Fergusson	2.09 (0.65)	0.001	954	7	WISC	Y	Y	-	-	-	-	Y	Y
Richards	0.98 (0.61)	0.109	511	8	SC	Y	Y	Y	-	-	-	-	-
NLSY	0.52 (0.36)	0.149	5475	10	PIAT	Y	Y	Y	Y	Y	Y	Y	-



Summary of studies that controlled for maternal IQ and other confounders as indicated. IQ tests: GOS=Groningen developmental scale; HOME=home observation for measurement of the environment scale; MDI=Bayley mental development index; PIAT=Peabody individual achievement test; SC=sentence completion; SES=socioeconomic status; WISC=Weschler child intelligence scale

feeding. The mean differences between both groups of siblings for PIAT scores were not significantly different from zero. In both cases, we also tested for any differences between the sibling pairs in the confounding factors used in the earlier analysis. None was significant, suggesting that the method controls for all those factors and there is no need for further analysis. In short, the sibling pairs analysis concurs with the earlier analysis in offering no support for a cognitive advantage of breast feeding once confounding is taken into account.

Meta-analysis

Our search yielded 431 references, 73 of which reported original data for full term infants. In 19 reports (12 studies) the analysis explicitly controlled for parental IQ and in one further report it implicitly controlled for parental IQ via sibling comparisons. The figure summarises eight of the 12 studies, together with the results for PIAT total score from our study. See bmj.com for exclusions. The studies with the biggest IQ advantage for breast feeding were those with smaller sample sizes and that controlled for fewer of the important additional confounders.

In the figure we have ordered the studies by decreasing standard error, and the asymmetric pattern of the effect estimates suggests publication bias. There is significant heterogeneity in their estimates of the effect of breast feeding ($Q=21.07$, $df=8$, $P=0.007$). This is consistent with the results from the longitudinal survey: maternal IQ explains most of the effect of breast feeding, but not all; other important confounders need to be taken into account. To adjust for this difference between studies we used the number of additional confounders in each study as a predictor of the effect of breast feeding in a meta-regression. Although a count is a somewhat simplistic summary measure, it did account for the heterogeneity (model $Q=7.41$, $df=1$, $P=0.006$; residual $Q=13.66$, $df=7$, $P=0.058$). The estimates equate to an IQ advantage of 3.37 points in a study controlling for IQ but no other confounders, and 0.16 of a point for a study with IQ and all eight additional confounders. With full control for covariates there is effectively no advantage to breast feeding. This result is not entirely due to the high weighting that this study has in the meta-regression; an unweighted meta-regression yielded an estimated advantage of breast

Table 2 Mutually adjusted effects of breast feeding and confounders on cognitive outcomes in 3161 mothers, 5475 children, and 16 744 assessments

Confounder	PIAT-total: B (SE)	P	Maths*: B (SE)	P	Reading*: B (SE)	P	Comprehension*: B (SE)	P
Breast feeding	0.52 (0.36)	0.149	0.52 (0.34)	0.130	0.36 (0.37)	0.332	0.52 (0.35)	0.134
Mother's AFQT score	4.43 (0.26)	<0.001	3.87 (0.25)	<0.001	3.77 (0.27)	<0.001	3.97 (0.25)	<0.001
Mother's education	1.03 (0.24)	<0.001	1.10 (0.23)	<0.001	0.96 (0.25)	<0.001	0.62 (0.23)	0.007
Family in poverty	–1.72 (0.41)	<0.001	–0.98 (0.39)	0.012	–1.70 (0.42)	<0.001	–1.82 (0.39)	<0.001
Mother's age	0.98 (0.20)	<0.001	0.72 (0.19)	<0.001	1.05 (0.20)	<0.001	0.69 (0.19)	<0.001
Mother smoked in pregnancy	0.08 (0.38)	0.839	0.37 (0.36)	0.305	–0.11 (0.39)	0.771	0.14 (0.36)	0.694
HOME cognitive stimulation	0.83 (0.10)	<0.001	0.78 (0.12)	<0.001	0.79 (0.11)	<0.001	1.13 (0.12)	<0.001
HOME emotional support	0.17 (0.09)	0.072	0.25 (0.11)	0.020	0.15 (0.10)	0.120	0.14 (0.11)	0.200
Birth weight	0.32 (0.16)	0.047	0.40 (0.15)	0.010	0.20 (0.17)	0.234	0.25 (0.16)	0.113
Birth order	–1.54 (0.18)	<0.001	–0.79 (0.17)	<0.001	–1.47 (0.19)	<0.001	–1.69 (0.18)	<0.001
Hispanic	–0.36 (0.52)	0.494	–1.85 (0.49)	<0.001	0.33 (0.53)	0.534	0.48 (0.49)	0.329
Black	–0.90 (0.50)	0.074	–2.79 (0.47)	<0.001	0.54 (0.52)	0.299	–0.03 (0.48)	0.950

PIAT=Peabody individual achievement test; AFQT=armed forces qualification test; HOME=home observation for measurement of the environment.
*Individual components of PIAT.

feeding of −0.39 for a fully controlled study (that is, a slight disadvantage).

We analysed the results from the only other study to have used sibling comparisons[13] separately and with the corresponding results from this study. The estimated standardised difference in means was 0.025 (SE = 0.041, P = 0.540) for breastfeeding status and 0.040 (0.036, P = 0.271) for duration of breast feeding. Thus, the evidence from the only two sibling pair studies to date, when taken together, offer no support for an advantage of breast feeding.

Discussion

Most of the observed association between breast feeding and cognitive development is the result of confounding by maternal intelligence. Level of cognitive stimulation at home, mother's educational attainment and age at the birth of the child, child's birth order, and family financial hardship all have independent effects. In fully adjusted analyses, the advantage of breast feeding was small and not significant.

Only a small proportion of the many studies that have shown a positive effect of breast feeding on children's cognitive ability control for maternal intelligence. By omitting this from the fully adjusted models, while leaving in maternal education and the other confounders, we have shown that maternal education is an imperfect surrogate. Our study was about five times the size of the largest previous study.[14] Heterogeneity between studies can be accounted for by the number of additional controls. The results lend little support to the hypothesis that breast feeding promotes intelligence in full term infants. The results from the sibling comparisons in our study and the two studies combined provide no support for a beneficial effect of breast feeding.

Wider application of results

This study and the others included in the meta-analysis are all based on samples from developed countries. Generalisation of the findings beyond these and similar societies would be unwise. We have also excluded premature and low birthweight infants for whom the effect may be different.

Evidence showing the many benefits of breast feeding for the child and mother led the World Health Organization and UNICEF to formulate the Innocenti Declaration, which includes exclusive breast feeding for 4-6 months as a global goal. Even if it does not enhance intelligence, breast feeding remains "an unequalled way of providing ideal food for the healthy growth and development of infants."[15]

We are grateful to Alex Ghys, Dale Hay, and Sandra Jacobson for providing data for the meta-analysis.

Contributors: See bmj.com.

Funding: GD is employed by the Medical Research Council. GDB is funded by a Wellcome advanced training fellowship and is also affiliated to the University of Edinburgh, Department of Psychology. IJD is the recipient of a Royal Society-Wolfson research merit award.

Competing interests: None declared.

Ethical approval: Not required.

1 Drane DL, Logemann JA. A critical evaluation of the evidence on the association between type of infant feeding and cognitive development. *Paediatr Perinat Epidemiol* 2000;14:349-56.

What is known already on this topic

Breast feeding has many benefits for both child and mother

Breastfed children tend to score higher on intelligence tests

There are important differences between mothers who breast feed and those who do not

What this study adds

The apparent effect of breast feeding on intelligence in offspring is accounted for by characteristics of the mother and the home environment

The mother's own intelligence plays the largest part in this explanation

2 Jain A, Concato J, Leventhal JM. How good is the evidence linking breastfeeding and intelligence? *Pediatrics* 2002;109:1044-53.
3 Bouchard T, McGue M. Genetic and environmental influences on human psychological differences. *J Neurobiol* 2003;54:4-45.
4 Silva PA, Buckfield P, Spears GF. Some maternal and child developmental characteristics associated with breast feeding: a report from the Dunedin multidisciplinary child developmental study. *Aust Paediatr J* 1978;14:265-8.
5 Center for Human Resource Research. *NLSY79 users guide*. Columbus, OH: Ohio State University, 2004.
6 Keck C. The initiation and duration of breastfeeding among employed women in the United States. Columbus, OH: Ohio State University, 1997 (PhD thesis).
7 Quo G, Harris KM. The mechanisms mediating the effects of poverty on children's intellectual development. *Demography* 2000;37:431-47.
8 Johnson DL, Swank PR, Howie VM, Baldwin CD, Owen M, Luttman D. Does HOME add to the prediction of child intelligence over and above SES? *J Genetic Psychol* 1993;154:33-40.
9 Pollock J. Long-term associations with infant feeding in a clinically advantaged population of babies. *Dev Med Child Neurol* 1994;36:429-40.
10 Anderson JW, Johnstone BM, Remley DT. Breast-feeding and cognitive development: a meta-analysis. *Am J Clin Nutr* 1999;70:525-35.
11 Rey J. Breastfeeding and cognitive development. *Acta Paediatr Suppl* 2003;92:11-8.
12 Caldwell BM, Bradley RH. *Home observation for measurement of the environment*. Little Rock, AR: University of Arkansas, 1984.
13 Evenhouse E, Reilly S. Improved estimates of the benefits of breastfeeding using sibling comparisons to reduce selection bias. *Health Services Res* 2005;40:1781-802.
14 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.
15 World Health Organization. *Global strategy for infant and young child feeding*. Geneva: WHO, 2000.

(Accepted 30 August 2006)

doi 10.1136/bmj.38978.699583.55

Endpiece

Cure the disease, kill the patient

As if you would call a physician, that is thought good for the cure of the disease you complain of but is unacquainted with your body, and therefore may put you in the way for a present cure but overthroweth your health in some other kind; and so cure the disease and kill the patient.

Francis Bacon (1561-1626)

Submitted by Ruth Green, senior house officer in anaesthetics, Royal Albert Edward Infirmary, Wigan

doi 10.1136/bmj.38958.625220.F7