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Original Article

# Breastfeeding and educational achievement at age 5

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**Abstract**

Our aim was to investigate whether the duration of breastfeeding, at all or exclusively, is associated with educational achievement at age 5. We used data from a prospective, population-based UK cohort study, the Millennium Cohort Study (MCS). 5489 children from White ethnic background born at term in 2000–2001, attending school in England in 2006, were included in our analyses. Educational achievement was measured using the Foundation Stage Profile (FSP), a statutory assessment undertaken by teachers at the end of the child's first school year. Breastfeeding duration was ascertained from interviews with the mother when the child was 9 months old. We used modified Poisson's regression to model the association of breastfeeding duration with having reached a good level of achievement overall (≥78 overall points and ≥6 in 'personal, social and emotional development' and 'communication, language and literacy' points) and in specific areas (≥6 points) of development. Children who had been breastfed for up to 2 months were more likely to have reached a good level of overall achievement [adjusted rate ratio (RR): 1.09, 95% confidence interval (CI): 1.01, 1.19] than never breastfed children. This association was more marked in children breastfed for 2–4 months (adjusted RR: 1.17, 95% CI: 1.07, 1.29) and in those breastfed for longer than 4 months (adjusted RR: 1.16, 95% CI: 1.07, 1.26). The associations of exclusive breastfeeding with the educational achievement were similar. Our findings suggest that longer duration of breastfeeding, at all or exclusively, is associated with better educational achievement at age 5.

*Keywords:* infant feeding, breastfeeding, FSP, Foundation Stage Profile.

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## Introduction

Educational achievement at school is an important predictor of later life academic and employment outcomes (Carneiro & Heckman 2005; Feinstein & Duckworth 2006). Previous research by our group as well as others has shown that breastfed children tend to perform better in tests of cognitive ability and have fewer behavioural problems than never breastfed children and there appears to be a graded association between the duration of breastfeeding and cognitive and behavioural assessment scores (Oddy *et al*. 2003, 2010a; Sacker *et al*. 2006; Ip *et al*. 2007; Kramer *et al*. 2008; Oken *et al*. 2008; Hansen *et al*. 2010; Heikkila



 

*et al*. 2011; Quigley *et al*. 2012). However, little is known of whether the cognitive advantage associated with the longer duration of breastfeeding translates into an association between breastfeeding and educational achievement in childhood. In a birth cohort of Brazilian males ($n = 2094$), breastfeeding was associated with high educational achievement in early adulthood, at age 18 (Victora *et al*. 2005). An Australian cohort study of 1038 children had similar findings, with children (particularly boys) who had been breastfed for 6 months or longer having higher academic scores than children breastfed for less than 6 months (Oddy *et al*. 2010b). If an association between breastfeeding and educational achievement exists, we would hypothesise that it would be evident from early childhood onwards. In order to examine this, we investigated the associations of breastfeeding duration and educational achievement in children aged 5, using data from a large, prospective UK cohort, the Millennium Cohort Study (MCS).

## Materials and methods

### MCS

The MCS is a nationally representative longitudinal study of infants born in the United Kingdom in 2000–2002, and the details of the study design and methods have been reported previously (Plewis 2004; Hansen *et al*. 2010). Briefly, a two-stage random sample of infants born in England and Wales between September 2000 and August 2001 and in Scotland and Northern Ireland between November 2000 and January 2002 were identified from the UK government Department of Work and Pensions Child Benefit records. The families of infants who were alive and living in the United Kingdom when the infant was 9 months old were contacted and invited to participate. The MCS sample was stratified by electoral ward and disadvantaged wards and those with high proportion of ethnic minority inhabitants were oversampled. Trained interviewers interviewed the parents when the children were approximately 9 months old and again at approximately 2-year intervals. The MCS was approved by the UK Multi-centre Research Ethics Committee.

### Participants

Our analyses were based on children in England because teacher-rated school achievement was measured differently in other UK countries, and these assessments would not have been comparable. Of the MCS children who took part at baseline ($n = 18\,467$), 3860 did not participate at age 5 and were excluded from our analyses. Children from the UK countries other than England ($n = 5502$) were excluded. We also excluded children from non-White ethnic backgrounds ($n = 2216$) because they tended to differ from White children in terms of breastfeeding duration (Griffiths *et al*. 2007) and Foundation Stage Profile (FSP) performance (Craxton 2008) and our sample was not large enough to fully incorporate these differences. Multiple births ($n = 101$) and preterm children ($n = 384$) were excluded from our analyses because there is evidence that their development is different from that of singleton and term children (Feldman & Eidelman 2005; Sutcliffe & Derom 2006). FSP data were not available for 729 children and 186 children had covariate data missing, and these children were excluded. Our study population consisted of 5489 White term-born singleton children who

**Key messages**

- We investigated whether the cognitive advantage previously observed in breastfed children when compared to never breastfed children translates into an association between breastfeeding and childhood educational achievement.
- In our analysis of 5489 children aged 5 years in England, breastfed children scored, on average, higher in a teacher-rated assessment of educational achievement than never breastfed children. The longer the children had been breastfed, the more likely they were to have reached a good level of educational achievement at age 5.

**Table 1.** Foundation Stage Profile outcomes

| Outcome definition | *n* (%) |
|---|---|
| Reached a good level of overall achievement: (≥78 across the 13 scales and ≥6 in all 'personal, social and development' scales and ≥6 in all 4 'communication, language and literacy' scales) | 2713 (49.4) |
| Reached a good level of achievement in 'personal, social and emotional development' (≥6 points in all 3 constituent scales) | 4103 (74.8) |
| Reached a good level of achievement in 'communication, language and literacy' (≥6 points in all 4 constituent scales) | 2924 (53.3) |
| Reached a good level of achievement in 'problem solving, reasoning and numeracy' (≥6 points in all 3 constituent scales) | 3872 (70.5) |
| Reached a good level of achievement in 'knowledge and understanding of the world' (≥6 points) | 4473 (81.5) |
| Reached a good level of achievement in 'physical development' (≥6 points) | 4954 (90.3) |
| Reached a good level of achievement in 'creative development' (≥6 points) | 4487 (81.8) |
| Total | 5489 |

participated at baseline and aged 5, and had complete data on breastfeeding, the educational outcome measure (FSP) and potential confounders.

### Exposures and outcomes

The duration and exclusivity of breastfeeding were ascertained from the baseline interview, where the mothers were asked whether they ever tried to breastfeed the cohort child, how old the cohort child was when s/he last received breast milk and how old the cohort child was when s/he first received formula, other milks or solid food. Breastfeeding was defined as exclusive if the cohort child had not received formula, other milks or solid food. The mothers were not specifically asked whether the children received water in addition to breast milk. The duration of any and exclusive breastfeeding were categorised into never, <2.0 months, 2.0–3.9 months and ≥4.0 months (Supporting Information Table S1).

The FSP is a statutory assessment tool in state schools in England and the data on the FSP were obtained by linking the MCS records to the school assessment information collected by the UK government Department for Children, Schools and Families (Hansen *et al*. 2010). Teachers are trained to conduct the FSP assessments and complete these for each child at the end of their first year at school (Hansen *et al*. 2010). Based on continuous observation of the child throughout the year, the teacher rates a child on 13 assessment scales across six areas of development (Table 1). The teacher gives the child 1–9 points on each scale, with higher points indicating better achievement.

We examined the FSP as a binary and as a continuous outcome. The main outcome in our analyses was having reached a good level of overall achievement. Secondary outcomes were having reached a good level of achievement in the six areas of development, which constitutes the FSP assessment. These definitions are used by the government and Local Authorities in the United Kingdom to assess the progress made by schools and Local Authorities in the field of early learning (Schools Analysis and Research Division, Department of Education 2010). A total score of ≥78 points across the 13 scales and a score of ≥6 in each of the three 'personal, social and emotional development' scales and the four 'communication, language and literacy' scales is defined as 'having reached a good level of overall achievement'. A scale score of ≥6 points in all scales belonging to an area of development was defined as 'having reached a good level of achievement' in that area (Table 1). For the models with continuous outcomes, the total FSP score was calculated by adding up the scores of all the subscales (areas of development) and the sub-scale scores by adding up the item scores from each subscale.

### Covariates

We adjusted our models for two sets of covariates. Our minimum-adjusted models were adjusted for the following socio-economic and health factors: mother's age at Sweep 1 (<20, 20–24, 25–29, 29–34 and 35+ years); mother's education level at Sweep 1 (National Vocational Qualification [NVQ] groups: NVQ 1–2, equivalent to secondary school qualifications; NVQ3, equivalent to A-level qualifications; NVQ 4–5, equiva-

lent to university-level qualification; no qualification/other qualification); mother's smoking during pregnancy (yes vs. no); and mother's relationship status when the baby was 9 months old (lone parent vs. not lone parent) and baby's admission to a neonatal unit (yes vs. no) (Ip *et al*. 2007; Thulier & Mercer 2009), household socio-economic position (based on the highest classified occupation held by the mother or her partner at Sweeps 1–3 and coded using the UK National Statistics Socio-economic Classification as follows: managerial/professional, intermediate, routine/manual, never worked/long-term unemployed) (Office for National Statistics 2005), mother's mental health (measured using Malaise Inventory scale at Sweep 1 (quintiles) and Kessler scale at Sweep 3 (quintiles) (Kessler & Mroczek 1994; Rodgers *et al*. 1999; Kessler *et al*. 2002). Fully adjusted models were adjusted for all the covariates in the minimum-adjusted models as well as the following indicators of the mother's parenting beliefs and behaviours: mother's reading to the child everyday at Sweep 3 (yes vs. no), type of child care the child attended at Sweeps 1 and 3 (formal: nursery, childminder or similar; informal: with family members; none: no child care attended), age when the child started child care between Sweeps 1 and 3 (months) and the number of other children the mother had at Sweep 1 (1, 2 and 3+).

### Models

We used risk ratios from modified Poisson's regression models to investigate the associations of breastfeeding duration with the binary FSP outcomes because the outcomes were not rare (Table 1) and odds ratios would have been likely to overestimate any associations (Zou 2004). With this approach, robust standard errors are calculated and used to estimate confidence intervals (CIs) that are wider than in the standard Poisson's regression, thus accounting for the uncertainty in the association estimates. Linear regression was used to investigate the associations between breastfeeding with the total FSP score and FSP sub-scores corresponding to the six areas of development. We ran unadjusted, minimum-adjusted and fully adjusted models for all exposure-outcome pairs. Stata's survey commands were used, with country-specific sampling and longitudinal weights to adjust for the unequal probability of the participants being included in the study and non-response between Sweeps 1 and 3. All analyses were conducted using Stata SE 10.1 (Stata Corporation, College Station, TX, USA).

## Results

The characteristics of the children included in our analyses are shown in Table 2. Of the 5489 children included in our analyses, 3798 children (69%) had ever been breastfed, 32% had been breastfed for at least 4 months and 16% had been exclusively breastfed for at least 4 months. Among the children who were breastfed for at least 4 months, 50% were exclusively breastfed for at least 4 months, 32% were exclusively breastfed for 2–3.9 months and 18% were exclusively breastfed for <2 months (Supporting

**Table 2.** Participant characteristics ($n = 5489$)

| Breastfeeding | *n* (%) children or mean (SD) covariate |
|---|---|
| Ever been breastfed, *n (%)* | 3798 (69.2) |
| Breastfed for ≥4 months, *n (%)* | 1767 (32.2) |
| Exclusively breastfed for ≥4 months, *n (%)* | 884 (16.1) |
| FSP score | |
| Total FSP, *mean (SD)* | 88.3 (17.8) |
| Pregnancy and perinatal factors | |
| Mother smoked during pregnancy, *n (%)* | 1241 (22.6) |
| Child admitted to neonatal unit, *n (%)* | 304 (5.5) |
| Mother's age <24 at baseline years, *n (%)* | 1137 (20.7) |
| Early childhood factors | |
| Mother's low educational level (NVQ 1–2 or equivalent)*, *n (%)* | 2356 (42.9) |
| Low occupational household SEP†, *n (%)* | 337 (6.1) |
| Mother single parent, *n (%)* | 721 (13.1) |
| Malaise scale (when child was 9 months old), *mean (SD)* | 3.08 (3.7) |
| Age started any child care (months), *mean (SD)* | 16.6 (14.5) |
| Ever (at Sweep 1 or 3) attended formal child care, *n (%)* | 4215 (76.8) |

FSP, Foundation Stage Profile; SD, standard deviation. *NVQ, National Vocational Qualification. Levels 4–5 are approximately equivalent to university degree, level 3 is approximately equivalent to A-levels, levels 1–2 are approximately equivalent to secondary school. †Low household SEP (routine/manual, never worked/unemployed).

**Table 3.** Summary of associations of breastfeeding with having reached a good level of overall achievement

| Participants ($n = 5489$) | $n$ (%) having reached good level of overall achievement | RR (rate ratio, compared to never breastfed children) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Unadjusted RR (95% CI) | *P* | Minimum adjusted* RR (95% CI) | *P* | Fully adjusted† RR (95% CI) | *P* |
| Never breastfed ($n = 1691$) | 629 (37.2) | 1 (ref.) | | 1 (ref.) | | 1 (ref.) | |
| Breastfed for: | | | | | | | |
| <2.0 months ($n = 1460$) | 711 (48.7) | 1.28 (1.18, 1 38) | <0.0001 | 1.13 (1.04, 1.22) | 0.003 | 1.09 (1.01, 1.19) | 0.028 |
| 2.0–3.9 months ($n = 571$) | 318 (55.7) | 1.47 (1.34, 1.61) | <0.0001 | 1.20 (1.09, 1.32) | <0.0001 | 1.17 (1.07, 1.29) | 0.001 |
| ≥4.0 months ($n = 1767$) | 1055 (59.7) | 1.57 (1.44, 1.69) | <0.0001 | 1.18 (1.09, 1.28) | <0.0001 | 1.16 (1.07, 1.26) | <0.0001 |
| Exclusively breastfed for: | | | | | | | |
| <2.0 months ($n = 1973$) | 1018 (51.6) | 1.36 (1.25, 1.46) | <0.0001 | 1.15 (1.07, 1.24) | <0.0001 | 1.12 (1.04, 1.21) | 0.004 |
| 2.0–3.9 months ($n = 941$) | 533 (56.6) | 1.46 (1.34, 1.60) | <0.0001 | 1.15 (1.06, 1.26) | 0.001 | 1.13 (1.04, 1.22) | 0.005 |
| ≥4.0 months ($n = 884$) | 533 (60.3) | 1.60 (1.47, 1.75) | <0.0001 | 1.19 (1.10, 1.30) | <0.0001 | 1.18 (1.08, 1.28) | <0.0001 |

CI, confidence interval. *Adjusted for mother's education (categories: NVQ 4 + 5 or equivalent, NVQ 3 or equivalent, NVQ 1 + 2 or equivalent, other), household SEP (categories: managerial/professional, intermediate, routine/manual, never worked/unemployed), Malaise scale (quintiles), Kessler scale (quintiles), mother's age (categories: < 20, 20–24, 25–29, 30–34 and 35+), mother's smoking during pregnancy: (yes vs. no), mother's relationship status (single parent vs. not single parent), baby admitted to a neonatal unit (yes/no). †Adjusted for all covariates in the minimum-adjusted models + mother reads to child everyday (yes vs. no), type of child care (formal, informal, none), age when the child started attending child care (continuous, months) and mother's number of other children (1, 2 and 3+).

Information Table S1). Overall, 2713 children (49.4%) had reached a good level of overall achievement by the end of their first year at school.

Children who had been breastfed were more likely to have reached a good level of achievement than children who had never been breastfed (Table 3). The proportions of children who had reached a good level of achievement were larger in the categories of children who had been breastfed for longer. In the unadjusted models, children who had received any breastfeeding were 28–57% more likely to have achieved a good level of overall achievement than never breastfed children. Adjustment for two sets of potential confounders attenuated these estimates towards, but not to, the null. The associations were similar in the analyses comparing the duration of exclusive breastfeeding to no breastfeeding. In the fully adjusted models, children who had been exclusively breastfed for up to 2 months were, on average, 9% more likely to have reached a good level of overall achievement [rate ratio (RR): 1.09, 95% CI: 1.01, 1.19] than never breastfed children. This association was more marked in children who had been exclusively breastfed for 2–4 months (RR: 1.17, 95% CI: 1.07, 1.29) and longer than 4 months (RR: 1.16, 95% CI: 1.07, 1.26). The associations of breastfeeding duration with a good level of achievement overall and a good level of achievement in the six specific areas of development were generally similar and consistent, with none of the specific areas markedly driving the observed associations (Table 4). However, the evidence for an association was somewhat stronger for communication, language and literacy, knowledge and understanding of the world, and physical development than for the other areas of development, with narrower CIs for the estimates.

The findings of the analyses with the FSP scores as continuous outcomes were similar to our main findings and are presented in Supporting Information Tables S1 and S2. Longer duration of breastfeeding was associated with higher overall FSP score as well as higher FSP sub-scores.

## Discussion

In our analyses of White, singleton children in England, 49% had reached a good level of overall achievement by the end of their first year at school in 2006. The proportion was much higher for the six individual areas of learning and was at least 70% for five of the six areas of learning (Table 1). These proportions are in agreement with the average performance of children in England. Nationally, the FSP assessment performance has steadily increased over

**Table 4.** Associations of breastfeeding with having reached good level of achievement in specific areas of development

| Participants | *n* (%) having reached good level of achievement | RR (rate ratio, when compared to never breastfed children) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Unadjusted RR (95% CI) | *P* | Minimum adjusted* RR (95% CI) | *P* | Fully adjusted† RR (95% CI) | *P* |
| Personal, social and emotional | | | | | | | |
| Never breastfed (*n* = 1691) | 1138 (76.3) | 1 (ref.) | | 1 (ref.) | | 1 (ref.) | |
| Breastfed for: | | | | | | | |
| <2 months (*n* = 1460) | 1089 (74.6) | 1.10 (1.06, 1.16) | <0.0001 | 1.04 (1.00, 1.09) | 0.06 | 1.03 (0.99, 1.07) | 0.2 |
| 2–3 months (*n* = 571) | 427 (74.7) | 1.10 (1.03, 1.17) | 0.003 | 1.00 (0.94, 1.06) | 0.9 | 0.99 (0.93, 1.05) | 0.8 |
| ≥4 months (*n* = 1767) | 1449 (82.0) | 1.21 (1.16, 1.27) | <0.0001 | 1.05 (1.01, 1.10) | 0.014 | 1.05 (1.01, 1.10) | 0.015 |
| Exclusively breastfed for: | | | | | | | |
| <2 months (*n* = 1973) | 1499 (76.0) | 1.13 (1.08, 1.18) | <0.0001 | 1.04 (1.00, 1.09) | 0.047 | 1.03 (0.99, 1.07) | 0.1 |
| 2–3 months (*n* = 941) | 736 (78.2) | 1.15 (1.09, 1.21) | <0.0001 | 1.02 (0.97, 1.08) | 0.4 | 1.02 (0.97, 1.07) | 0.5 |
| ≥4 months (*n* = 884) | 730 (82.6) | 1.22 (1.16, 1.29) | <0.0001 | 1.06 (1.01, 1.11) | 0.025 | 1.06 (1.01, 1.11) | 0.023 |
| Communication, language and literacy | | | | | | | |
| Never breastfed (*n* = 1691) | 695 (41.1) | 1 (ref.) | | 1 (ref.) | | 1 (ref.) | |
| Breastfed for: | | | | | | | |
| <2 months (*n* = 1460) | 770 (52.7) | 1.27 (1.17, 1.37) | <0.0001 | 1.13 (1.05, 1.21) | 0.002 | 1.09 (1.01, 1.18) | 0.019 |
| 2–3 months (*n* = 571) | 349 (61.1) | 1.46 (1.34, 1.59) | <0.0001 | 1.21 (1.12, 1.32) | <0.0001 | 1.18 (1.09, 1.28) | <0.0001 |
| ≥4 months (*n* = 1767) | 1110 (62.8) | 1.50 (1.39, 1.61) | <0.0001 | 1.15 (1.07, 1.23) | <0.0001 | 1.13 (1.05, 1.21) | 0.001 |
| Exclusively breastfed for: | | | | | | | |
| <2 months (*n* = 1973) | 1101 (55.8) | 1.34 (1.25, 1.44) | <0.0001 | 1.15 (1.07, 1.23) | <0.0001 | 1.11 (1.04, 1.19) | 0.003 |
| 2–3 months (*n* = 941) | 569 (60.5) | 1.43 (1.32, 1.54) | <0.0001 | 1.14 (1.06, 1.23) | <0.0001 | 1.12 (1.04, 1.20) | 0.003 |
| ≥4 months (*n* = 884) | 559 (63.2) | 1.52 (1.41, 1.65) | <0.0001 | 1.16 (1.07, 1.25) | <0.0001 | 1.14 (1.05, 1.23) | 0.002 |
| Problem solving, reasoning and numeracy | | | | | | | |
| Never breastfed (*n* = 1691) | 1027 (60.7) | 1 (ref.) | | 1 (ref.) | | 1 (ref.) | |
| Breastfed for: | | | | | | | |
| <2 months (*n* = 1460) | 1013 (69.4) | 1.13 (1.07, 1.20) | <0.0001 | 1.05 (0.99, 1.10) | 0.08 | 1.03 (0.98, 1.09) | 0.2 |
| 2–3 months (*n* = 571) | 424 (74.3) | 1.21 (1.13, 1.29) | <0.0001 | 1.06 (1.00, 1.13) | 0.048 | 1.05 (0.99, 1.11) | 0.1 |
| ≥4 months (*n* = 1767) | 1408 (79.7) | 1.30 (1.24, 1.37) | <0.0001 | 1.09 (1.04, 1.14) | <0.0001 | 1.08 (1.04, 1.13) | <0.0001 |
| Exclusively breastfed for: | | | | | | | |
| <2 months (*n* = 1973) | 1410 (71.5) | 1.17 (1.11, 1 23) | <0.0001 | 1.05 (1.01, 1.11) | 0.028 | 1.04 (0.99, 1.09) | 0.1 |
| 2–3 months (*n* = 941) | 715 (76.0) | 1.24 (1.17, 1.31) | <0.0001 | 1.07 (1.01, 1.12) | 0.013 | 1.06 (1.01, 1.12) | 0.031 |
| ≥4 months (*n* = 884) | 720 (81.5) | 1.33 (1.26, 1.40) | <0.0001 | 1.10 (1.05, 1 16) | <0.0001 | 1.12 (1.04, 1.15) | <0.0001 |
| Knowledge and understanding of the world | | | | | | | |
| Never breastfed (*n* = 1691) | 1238 (73.2) | 1 (ref.) | | 1 (ref.) | | 1 (ref.) | |
| Breastfed for: | | | | | | | |
| <2 months (*n* = 1460) | 1211 (83.0) | 1.13 (1.08, 1.17) | <0.0001 | 1.08 (1.04, 1.12) | <0.0001 | 1.07 (1.03, 1.11) | 0.001 |
| 2–3 months (*n* = 571) | 479 (83.9) | 1.14 (1.09, 1.20) | <0.0001 | 1.06 (1.02, 1.11) | 0.005 | 1.05 (1.01, 1.10) | 0.016 |
| ≥4 months (*n* = 1767) | 1545 (87.4) | 1.19 (1.14, 1.24) | <0.0001 | 1.08 (1.04, 1.12) | <0.0001 | 1.07 (1.03, 1.11) | <0.0001 |
| Exclusively breastfed for: | | | | | | | |
| <2 months (*n* = 1973) | 1660 (84.1) | 1.14 (1.10, 1.19) | <0.0001 | 1.08 (1.04, 1.12) | <0.0001 | 1.07 (1.03, 1.11) | <0.0001 |
| 2–3 months (*n* = 941) | 799 (84.9) | 1.16 (1.11, 1.21) | <0.0001 | 1.07 (1.03, 1.11) | 0.001 | 1.06 (1.02, 1.10) | 0.003 |
| ≥4 months (*n* = 884) | 776 (87.8) | 1.19 (1.14, 1.24) | <0.0001 | 1.07 (1.03, 1.12) | <0.0001 | 1.07 (1.03, 1.11) | 0.001 |
| Physical development | | | | | | | |
| Never breastfed (*n* = 1691) | 1448 (85.6) | 1 (ref.) | | 1 (ref.) | | 1 (ref.) | |
| Breastfed for: | | | | | | | |
| <2 months (*n* = 1460) | 1324 (90.7) | 1.06 (1.03, 1.09) | <0.0001 | 1.04 (1.01, 1.07) | 0.007 | 1.03 (1.01, 1.06) | 0.019 |
| 2–3 months (*n* = 571) | 531 (93.0) | 1.08 (1.04, 1.12) | 0.001 | 1.04 (1.01, 1.08) | 0.022 | 1.04 (1.00, 1.08) | 0.031 |
| ≥4 months (*n* = 1767) | 1651 (93.4) | 1.09 (1.06, 1.11) | <0.0001 | 1.04 (1.01, 1.07) | 0.004 | 1.04 (1.01, 1.07) | 0.004 |
| Exclusively breastfed for: | | | | | | | |
| <2 months (*n* = 1973) | 1802 (91.3) | 1.06 (1.04, 1.09) | <0.0001 | 1.04 (1.01, 1.06) | 0.006 | 1.03 (1.01, 1.06) | 0.014 |
| 2–3 months (*n* = 941) | 871 (92.6) | 1.08 (1.05, 1.11) | <0.0001 | 1.04 (1.01, 1.07) | 0.01 | 1.04 (1.01, 1.07) | 0.015 |
| ≥4 months (*n* = 884) | 833 (94.2) | 1.09 (1.06, 1.12) | <0.0001 | 1.04 (1.01, 1.07) | 0.003 | 1.04 (1.01, 1.07) | 0.003 |

**Table 4.** Continued

| Participants | *n* (%) having reached good level of achievement | RR (rate ratio, when compared to never breastfed children) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Unadjusted RR (95% CI) | *P* | Minimum adjusted* RR (95% CI) | *P* | Fully adjusted† RR (95% CI) | *P* |
| Creative development | | | | | | | |
| Never breastfed (*n* = 1691) | 1258 (74.4) | 1 (ref.) | | 1 (ref.) | | 1 (ref.) | |
| Breastfed for: | | | | | | | |
| <2 months (*n* = 1460) | 1194 (81.8) | 1.09 (1.05, 1.13) | <0.0001 | 1.05 (1.00, 1.09) | 0.019 | 1.04 (1.00, 1.08) | 0.072 |
| 2–3 months (*n* = 571) | 480 (84.1) | 1.11 (1.05 (1.17) | <0.0001 | 1.04 (0.99, 1.09) | 0.1 | 1.03 (0.98, 1.08) | 0.2 |
| ≥4 months (*n* = 1767) | 1555 (88.0) | 1.17 (1.12, 1.22) | <0.0001 | 1.07 (1.03, 1.11) | 0.002 | 1.07 (1.02, 1.09) | 0.002 |
| Exclusively breastfed for: | | | | | | | |
| <2 months (*n* = 1973) | 1647 (83.5) | 1.11 (1.07, 1.15) | <0.0001 | 1.05 (1.02, 1.09) | 0.006 | 1.04 (1.01, 1.08) | 0.025 |
| 2–3 months (*n* = 941) | 808 (85.9) | 1.14 (1.09, 1.19) | <0.0001 | 1.06 (1.01, 1.10) | 0.016 | 1.05 (1.00, 1.09) | 0.032 |
| ≥4 months (*n* = 884) | 774 (87.6) | 1.16 (1.11, 1.21) | <0.0001 | 1.05 (1.01, 1.10) | 0.018 | 1.05 (1.01, 1.10) | 0.018 |

CI, confidence interval; SD, standard deviation. *Adjusted for mother's education (categories: NVQ 4 + 5 or equivalent, NVQ 3 or equivalent, NVQ 1 + 2 or equivalent, other), household SEP (categories: managerial/professional, intermediate, routine/manual, never worked/unemployed), Malaise scale (quintiles), Kessler scale (quintiles), mother's age (categories: <20, 20–24, 25–29, 30–34 and 35+), mother's smoking during pregnancy: (yes vs. no), mother's relationship status (single parent vs. not single parent), baby admitted to a neonatal unit (yes/no). †Adjusted for all covariates in the minimum-adjusted models + mother reads to child everyday (yes vs. no), type of child care (formal, informal, none), age when the child started attending child care (continuous, months) and mother's number of other children (1, 2 and 3+).

the past few years (Schools Analysis and Research Division, Department of Education 2010).

In our analyses, by the age of 5 breastfed children had reached a higher level of development in a teacher-rated assessment of educational achievement than never breastfed children. There was also some evidence for an association between longer duration of breastfeeding, particularly exclusive breastfeeding, and higher scores in the assessment of educational achievement. Generally, these associations remained even after adjustment for maternal and early childhood socio-economic, educational and other potential confounders. Our findings were similar in the analyses with the overall educational achievement regardless of whether the latter was modelled as a binary or a continuous outcome (proportion having reached a good level of overall achievement or the mean total FSP score). We found no clear evidence that any of the six areas of development would particularly drive these associations, as the effect estimates in these six areas were similar to the estimates of the effect on the overall achievement and consistent with one another.

The observed association between the longer duration of breastfeeding and better educational achievement during the early years of school may be due to better cognitive and behavioural development in breastfed children, which has been shown in previous studies by our group (Sacker *et al.* 2006; Heikkila *et al.* 2011; Quigley *et al.* 2012) as well as others (Ip *et al.* 2007; Kramer *et al.* 2008; Oddy *et al.* 2010a). Previous research suggests that infant feeding could influence child development through many biological or psychosocial mechanisms. For example, increased intake of the extensive range of essential fatty acids, oligosaccharides and other components of breast milk is likely to lead to improved neurological and cognitive development (Coppa *et al.* 2004, 2006; McCann & Ames 2005). There is also evidence that babies who are not breastfed are more prone to infectious illnesses than breastfed babies (Ip *et al.* 2007; Quigley *et al.* 2007), which may have an adverse impact on their social and cognitive development. Furthermore, breastfeeding could lead to more mother–baby interaction, thus improving the readiness and ability to learn and develop in a social setting (Britton *et al.* 2006; Denham *et al.* 2009).

Overall, the association estimates in our analyses were modest in size. Breastfed children were 10–16% more likely to have achieved a good overall level of development and the total FSP scores were, on

average, 2–3 points higher in breastfed children when compared to never breastfed children. The question for further research remains whether these small differences translate to differences in later educational, developmental or health outcomes. In our analyses, the strongest 'co-risk factors' for the association between breastfeeding duration and having reached a good level of educational achievement were mother's age and education, which are indeed known predictors of child cognitive development and educational achievement. In the fully adjusted models, the effect estimates for the ascending categories of mother's age and education, respectively, ranged from 1.20 to 1.25 and from 1.05 to 1.19 (all *P*-values <0.05), indicating that the older and more educated the mothers were, the more likely their children were to have reached a good level of achievement. Thus, the estimated effects of breastfeeding in our study were slightly weaker than the effect of mother's age and on a par with the effect of mother's education.

An important strength of our investigation was that we analysed data from a large prospective study and investigated a statutory measure of child educational achievement, the FSP assessment. Routinely collected data are becoming increasingly used in epidemiological research, as such data are available for a large portion of the population relatively cost-efficiently and have standardised definitions (Jones *et al*. 2010). The FSP has considerable potential for research use because it is widely available (this assessment is routinely done in all state schools and schools receiving some state funding in England) and is correlated with other educational outcomes such as the national assessments at age 7 ('Key Stage 1') (Schools Analysis and Research Division, Department of Education 2010). The assessments are conducted according to standard instructions by teachers, who are trained and experienced in assessing children and, importantly, who are not aware of whether or not the children were breastfed. Also, the FSP assessment is based on accumulated observations by the teacher throughout the school year and is thus not, unlike many other standard assessments, influenced by short-term, temporary changes in the child's development.

A further strength of our analysis was that our models were adjusted for a number of potential socio-economic and lifestyle confounders. However, no data were available in the MCS on mother's cognitive ability, such as intelligence quotient (IQ), which is an important determinant of a child's IQ as well as educational achievement (Der *et al*. 2006). We adjusted our analyses for mother's education as a proxy measure for her cognitive ability (Goodman & Gregg 2010) and found that this and the mother's age were indeed the two strongest confounders of the association of breastfeeding with the FSP outcomes. However, it is still possible that our findings have been influenced by residual confounding from mother's cognitive ability or other unmeasured confounders. Further research should investigate the associations between breastfeeding and early year educational outcomes in preterm children, twins and triplets, and children from ethnic minority backgrounds.

Breastfeeding duration in the MCS was ascertained from retrospective interviews with the mother, and there is evidence that maternal recall is a valid and reliable method of ascertaining breastfeeding initiation and duration (Li *et al*. 2005). However, it is possible that some recall bias may have arisen as a result of poor recall or desire to give the interviewer a socially acceptable answer, and this may have made our effect estimates imprecise. Also, the shortest breastfeeding duration category may be heterogeneous and include infants who received breast milk for a few days to those who were breastfed for up to 2 months. Such exposure misclassification may have reduced the accuracy of our effect estimates.

## Conclusions

We investigated the association between breastfeeding duration and teacher-assessed educational achievement in 5-year-old children in England. Our findings suggest that longer duration of breastfeeding, at all or exclusively, is associated with better educational achievement during the first year at school.

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## Conflicts of interest

The authors declare that they have no conflicts of interest.

## Contributions

All authors participated in generating hypotheses, planning and interpreting the analyses, as well as writing and critically reviewing the paper. KH analysed the data. KH and MQ wrote the first draft.

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## Supporting information

Additional Supporting Information may be found in the online version of this article:

**Table S1.** Any and exclusive breastfeeding in the children included in our analyses

**Table S2.** Associations of breastfeeding with total FSP score

**Table S3.** Associations of breastfeeding with FSP sub-scores